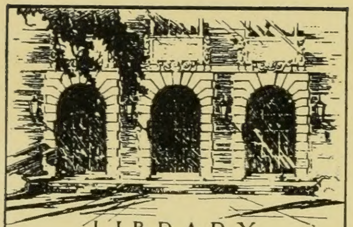

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THE

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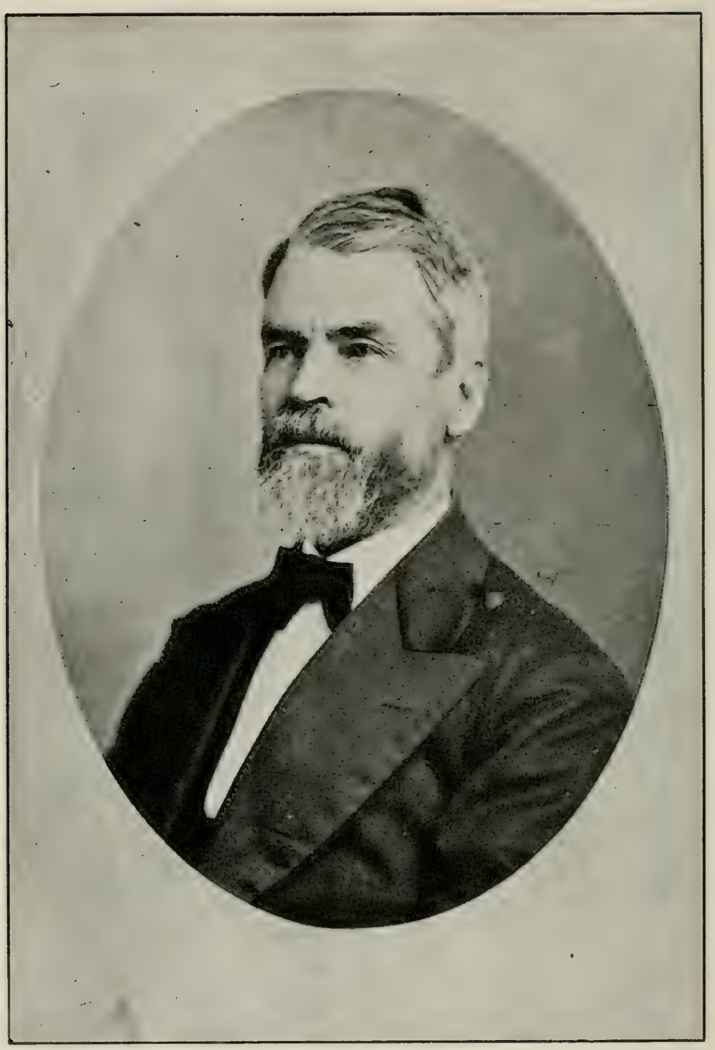

Yours very truly

I. A. Lapham

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THE

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INCREASE ALLEN LAPHAM.

By N. H. WINCHELL, Minneapolis.

It was a remarkable historical event which took place in Wisconsin about two years ago. The State Agricultural Society, holding its annual fair at Milwaukee, authorized the offer of a special premium* to the lady naming the most distinguished citizen (deceased) of the state of Wisconsin, presenting at the same time a sketch of his life. Nineteen papers were examined by the judges appointed by the society, of which five named the subject of this sketch; and after duly weighing the merits of each, and its reasons for choosing this or the other of the distinguished citizens of the state, the judges "decided that the author of No. 3 [in favor of Dr. I. A. Lapham], Mrs. Amelia W. Bate, of Milwaukee, is entitled to the premium." The committee further say:

> Permit us at the same time to add that we feel more than ordinary gratification in the general effect of this contest from the fact that, as present appearances indicate, it is more than likely to result in a proper recognition of the valuable life-services rendered Wisconsin by one of her most distinguished citizens.

It is probably the first instance in human history of the popular choice of a deceased scientist as a recipient of honor, above statesmen, financiers, lawyers, and educators. It was a deliberate, organized and well-executed canvass,† and the result is highly gratifying to the scientific men of the United States. It proves a growing appreciation of the value of science on the part of the intelligent and influential portion of the community.

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*Through A. W. Rich and Company, of Milwaukee.

†The plan and sketches are published in a pamphlet entitled: Biographical sketches of Increase Allen Lapham and other distinguished citizens of Wisconsin. Milwaukee, 1891, with portraits.

But while Dr. Lapham was a *scientist*, in the broad sense of the word, he was specially a *geologist*, and it is because of his alliance with science through the avenues of geological work that we desire to review succinctly his life and work in this series of sketches.*

Born in Palmyra, Wayne county, New York, March 7th, 1811, his father's family participated in the general westward flow of migration, removing first to Rochester and Lockport, where his father was engaged as a contractor in the construction of the Erie canal. He was one of thirteen children and had to do his share for the support of the family. He assisted his father as a stone-cutter, and later was aid to his older brother in laying out a road on the Canada side of the Niagara river, down the steep banks below the falls. He worked also on the Welland canal and on the Miami canal. In 1827 he was employed on the canal constructed round the falls of the Ohio, and in that year, at the age of sixteen, sent to Benjamin Silliman, editor of the *American Journal of Science and Arts*, "A notice of the Louisville and Shippingsport canal, and of the geology of the vicinity." It was illustrated by plans, geological sections and a map—all executed with artistic skill—and contained the first published notice of the occurrence of petroleum in the cavities of limestone rocks.† For three years subsequently he was assistant engineer on the Ohio canal, and lived at Portsmouth. In 1832 he published an article on the Geology of Ohio, in conjunction with his elder brother, giving observations on the distribution of the primitive and other boulders. These two brothers for several years worked together intimately, each writing to the other the new observations he made, or the new ideas he received from their separate rambles or in the prosecution of their engineering enterprises. This correspondence is full of scientific interest, and, if published, would doubtless prove of historical value. Every trip either of these brothers took, whether on business or pleasure, was followed by a letter to the other, fully describing the country through which he passed. In 1827 began his lifelong friendship and correspondence with Dr. Benjamin Silliman, of New Haven, editor of the American Journal of Science. Interesting and valuable scientific correspondence began at this date (1828) with Dr. Darlington, Thomas Say, Isaac Lea, Chester Dewey, Dr. S. P. Hildreth, Asa Gray, Dr. Troost, of Nashville, and most of the scientists of America. Nothing which appeared to be of scientific value escaped the eye of young Lapham. He collected shells, plants, insects, fossils, until his hands and his home were full. He presented many to special workers in special departments. Dr. Troost used his collections while preparing his history of American fossils, and Dr. Hildreth established several new species on specimens of shells sent by him. Victor G. Audubon, collecting for his father, was his frequent companion in his rambles about Louisville at this time. At the last his large collection was purchased and deposited in the University of Wisconsin, where it was burned when, in 1884, Science Hall of that institution was destroyed. This was a repetition of the catastrophe which befell the cabinet of Dr. D. D. Owen, at Bloomington, Indiana.

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*Miss Julia A. Lapham, Oconomowoc, Wis., has furnished a mass of historical memoranda from the manuscripts and records left by Dr. Lapham, for use in the preparation of this sketch, including scrap-books, unpublished scientific papers, letters and personal incidents. The author has also made use of a memorial of Dr. Lapham by Charles Mann, read before the Wisconsin Historical Society, and another by S. S. Sherman, read before the Old Settlers' Club, Milwaukee, Dec. 11, 1875.

†Op. cit., vol. XIV, p. 65, 1828.

One of the noble acts of his early manhood was prompted by the filial gratitude he entertained for his parents. In 1829 the brothers decided to buy a farm for their parents. Their united salary did not amount to more than $1,000 per year, but by careful economy for several years they had the satisfaction of seeing their parents and younger brothers and sisters in a home of their own. Like their father, these brothers were engineers, and it had been necessary that the family should move from place to place wherever their canal or road work called them.

While in Ohio, Lapham was concerned in the first movements for the "first survey" of that state. In 1836 he was a member of the committee appointed to investigate and report on the subject.* He did not, however, remain in Ohio long enough to become identified with it, as doubtless he would had he continued a citizen of that State. His lot was to be cast with a new commonwealth, where his manhood and his mental vigor were to expand as the manifold exigencies of a new State might call for them. Wisconsin was still a portion of the "Territory of Michigan," when, in July, 1836, he arrived at Milwaukee, then a village of 1,200 inhabitants, where "the red man still lingered and exchanged his furs for the products of civilization."

Thenceforward the life and public acts of Lapham are interwoven with the history of Wisconsin, and constitute some of the important threads of its warp. Although he was without the initial advantages of a liberal education, was averse to appearance in public, naturally retiring in manner and wholly unselfish in his scientific work, he accumulated a fund of knowledge and acquired a fluency of expression that made him the first authority in the Northwest on the varied questions of either natural or physical science that concerned his commonwealth. The exactness and multiplicity of his observations and the carefulness of his deductions, based on the engineering training of his early years combined to render his writings both detailed and comprehensive, and to give him a rank among the first scientists of his day in several of the scientific fields in which he labored. Most American scientists, fifty or sixty years ago, embraced all natural science. Lapham neglected none. Beginning with the record of weather observations at Louisville, and the publication of them in the local newspapers, he pushed his meteorological studies so vigorously and judiciously that, through his efforts largely, the government was induced to organize the "Signal Service" observations and predictions of the weather. The collection of arrow-points in Ohio was continued in Wisconsin, and was extended to the completion of a survey of the aboriginal mounds of Wisconsin, which was published as a quarto volume by the Smithsonian Institution. From the amateur in botany, collecting for himself, he organized a grand scheme for the thorough study and illustration

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*Ohio State Docs., 1837, p. 31 (Sherman). See *Am. Jour. Sci.*, (1), XXXII, p. 190, for a notice of the report rendered by this committee.

of the grasses of the United States. This eventuated in a large manuscript volume, yet in existence, but unpublished, and in a very large herbarium said to consist of 24,000 specimens and 8,000 species, embracing the whole range of the vegetable kingdom. Beginning with the study of the primitive boulders of Ohio, he continued his geological work in Wisconsin where he was soon recognized as the first authority in the state, and was made "chief geologist" of the state survey, organized in 1873. He made valuable contributions also to the natural history, the statistics, the topography, the cartography, the civil history and the educational affairs of his state. In science he was a cosmopolitan. He said his particular department was the "study of Wisconsin." This is a simple but expressive statement of the nature and variety of his scientific pursuits. He lived for many years in Milwaukee. He died of heart disease, suddenly, while alone in a small row boat on lake Oconomowoc, while visiting his son whose farm was on the bank of that lake. Born in 1811, he was 64 years of age at his death.

Dr. Lapham was for Wisconsin what David Dale Owen was for Indiana, and Douglass Houghton for Michigan. But he was also more than these. They were pioneer organizers and light-bearers for the succeeding generation in the line of geology simply. They started the first surveys, and by their intelligent and industrious labor they laid the foundations of the science in their states. Lapham spent the major portion of his life in allied sciences, and came to the near consummation of his full expectation in geological science near the close of his days—when he was appointed by Gov. Washburn to conduct the geological survey of Wisconsin. He was well known as an archeologist for many years prior, and as a climatologist the Government had recognized his superior qualifications. As a botanist he was the constant correspondent and coadjutor of most of the botanists of the country, and had made numerous contributions to their herbaria, as well as to the botanical literature of the day. L. Agassiz sought his aid in zoology; and as cartographer and general physicist every one in Wisconsin consulted him. He had made an important discovery of certain markings in iron meteorites, since named Laphamite markings. There was, therefore, a universal concord in demanding his appointment. No one else knew so much about the state as he, and he had evinced his capacity for conducting such a research into its natural features. Lapham, therefore, was more than a geologist when he undertook the survey of Wisconsin; he was fortified for the task by many years of the most diversified training and experience.

In reviewing his life and work, therefore, while this sketch naturally dwells most on his geological work, it would obviously be a partial and very imperfect account, if it omitted to present briefly his other scientific contributions. His most elaborate finished work was, perhaps, his description and illustration of the aboriginal earth-works of Wisconsin, published by the Smithsonian Institution, but his most lengthy and persistent was his geological. This he began as a youth, and this he laid down but a few months before his death.

We can divide his works, so far as published, under the following heads:

1. Botanical; 2. Climatological; 3. Archeological; 4. Cartographical; 5. Geological; and 6. Miscellaneous.

1. Botanical Work.

Lapham was familiar with the botany of the phænogamous plants before he arrived in Wisconsin. He at once began a systematic, careful cataloguing of the plants of the state. He was an excellent draughtsman. Some of the delicate drawings of the minute parts of grasses, contained in his unpublished "Gramineæ of the United States," have almost the exact shadings of lithographs. In 1836 he ventured to print a "catalogue of the plants and shells found in the vicinity of Milwaukee."* In 1838, and again in 1840 he reissued this catalogue with many additions. In the first volume of the Transactions of the Wisconsin State Agricultural Society is an admirable treatise of nearly one hundred pages, on the "Grasses of Wisconsin and adjoining states." He pursued the subject of the grasses of the country with great eagerness, and

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*"My first acquaintance with Dr. Lapham was in 1846, when one morning there landed [at Racine] from the steamer Sultana a small man with a large collecting box hanging at his side. He came from Milwaukee and intended returning on foot along the lake shore in order to collect plants and shells—no easy journey, encumbered, as he soon would be, with a well-filled specimen box. He spoke lightly of the undertaking, saying he had performed similar feats before." Dr. P. R. Hoy, in *Trans. Wis. Acad. Sci., Arts and Let., vol. iii, p. 265.*

did not content himself with anything less than a comprehensive study and cataloguing of the grasses of North America. He approached this great enterprise through the bureau of Agriculture of the Patent Office, suggesting that the agriculturists of the country would be greatly interested in a thorough investigation and final description of all the native Gramineæ, not omitting those naturalized. His suggestion was approved, an appropriation was made by Congress, Dr. Lapham was invited to Washington and entered upon the preliminary work under the direction of the Commissioner of Patents. He began a systematic collection, and at the same time a systematic series of drawings and studies. He was to collect seeds for distribution and experimental purposes, and to make a report that should include the botanical description, geographical distribution, time of flowering, sowing and harvesting, in different latitudes; the culture, soil and climate best adapted to each species, and all other facts relating to its economic value. He was also to conduct an expedition to the West Indies and South America for collecting improved varieties of sugar cane, for the use of the planters of Louisiana, a liberal appropriation having been made for that purpose. Considering the manifold ways in which the grasses of the country enter into the labor of the farming industry, and the fundamental importance of agricultural labor and skill in the industrial economy of the country, it is difficult to conceive of a more far-reaching measure for fostering and furthering the immediate good of the whole nation. After a personal expense of about a thousand dollars and a labor of several months, in preliminary arrangements, Dr. Lapham was informed by the higher authority residing in the [new] Secretary of the Interior, that his first bill of expense, including his first quarter's salary, could not be audited because his politics was not in accord with the party in power,—in short, that his appointment was not approved. The expedition to South America departed without him. His work was ignored and he was never remunerated. The matter was reviewed again just before the breaking out of the civil war, and the Agricultural Bureau gave it favorable consideration, but the national exigencies that soon absorbed all public attention put a stop to its execution. The enterprise therefore slumbers, but only slumbers, for it is so palpably an enterprise of national utility that it will not be allowed to die. The result of Dr. Lapham's labor was a manuscript descriptive catalogue of the known species of Gramineæ of the United States, still unpublished, though preserved among his archives by his children. It is accompanied by numerous elegant plates of drawings of the flowers and fructification, in pursuance of the plan outlined when the work was authorized by Congress.

Dr. Lapham contributed numerous papers to the Transactions of the Wisconsin Agricultural Society on the plants and trees of the state. In 1867 the Legislature ordered an inquiry into "the injurious effect of clearing land of forests, and the duty of the state in the matter." Dr. Lapham was appointed chairman of the Committee. He made an exhaustive report, which the Legislature printed as an octavo volume of over one hundred closely printed pages. This neglected volume, from which, as from a botanical cyclopedic thesaurus, a class of economic foresters and agricultural writers have for many years drawn exact knowledge concerning the effect of forests on the face of the country, on the climate, on the rainfall, on the healthfulness, the habitability, the productiveness and the aggregate value of the primeval country, attests the extended research and the sound, practical good sense which its author pre-eminently manifested in all his investigations. Dr. Asa Gray testified to the reliability of Lapham's botanical observations. He used Lapham's catalogue in determining the geographic distribution of western plants. He dedicated a new genus to Lapham, found in our southwestern frontiers (Laphamia), to which Dr. Gray assigned five species, and urged, after Lapham's death, that the herbarium which he had collected should be made the basis of a botanical museum, where it could be preserved permanently as a state or municipal memorial to one of the honored founders of the commonwealth of Wisconsin.

Dr. Lapham made a botanical excursion into Minnesota, extending his notes and collections entirely across the state, and to the valley of the Red river of the North. It was in connection with an ill-starred and futile attempt on the part of some speculating capitalists of Milwaukee to found a city in northwestern Minnesota that Lapham was induced to take charge of an expedition from St. Cloud across the uninhabited tracts westward to the objective point, which was about four miles southwest of the present city of Fergus Falls, in Otter Tail county. In the midst of the perplexing duties which fell upon him, and notwithstanding the harassing failures that constantly attended the enterprise, Dr. Lapham succeeded in collecting a large herbarium of this region, and he made a very full catalogue of all species which he saw, with notes of habitat and distribution. With characteristic generosity and cosmopolitan love for science he donated this catalogue to the Minnesota survey in 1873. It was published in 1875,* and was the first systematic attempt to classify the flora of the state with any noteworthy degree of success.

Although Dr. Lapham was not able in the later years of his life to devote so much time to his favorite science, yet in one of the latest of his scientific papers he reverts to his first love, and dedicates to botany one of the ripest results of a life of scientific study. The thought embodied in "The Law of embryonic development, the same in plants as in animals," (American Naturalist, Vol. IX, May, 1875,) is based on a profound knowledge of organic development. He attempts "to show that the same law of resemblance, between the immature of one order and the mature of a lower order of animals, is equally true in the vegetable world, where its study may lead to results of equal importance."† He compares some of the low vegetable forms, such as the desmids, consisting of a single cell which never develops to anything higher than a desmid, though manifesting the essential functions of a perfect plant, to the fovilla of a pollen-grain from the stamen of some of the higher phænogams. Next higher he mentions the minute one-celled Protococcus packed with minute particles, each one, under favorable circumstances, destined to become an independent plant. This still further simulates the pollen-grain which, under favorable circumstances (as falling upon the stigma), also sends downward a growth which performs the office of originating a new plant. Fungi, still higher,

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***A catalogue of the plants of Minnesota.* Prepared in 1865 by I. A Lapham. Trans. Minn. State Hort. Soc., 1875.

†Wisconsin Academy of Sciences, Arts and Letters, Vol. III, 1875, pp. 110-113.

scatter little cases or sacks, filled with little grains called spores, which, if they light in favorable places, grow and become mould again. The little grains of pollen, of the higher orders, are thus shown to be specialized forms of the lower orders in their maturity.

Dr. Lapham's botanical collection, gathered mostly between 1830 and 1855, embraced, according to Prof. J. C. Arthur, 24,000 specimens, representing the whole range of the vegetable kingdom in 8,000 species, and was tastefully arranged in the most approved style in genus and species covers, and carefully labelled. After his death it was purchased by the State of Wisconsin and deposited in the University at Madison.

2. *Climatological Work.*

One of the great accomplishments and triumphs of Lapham's life was the establishment of the Weather Service bureau. From the time of his earliest scientific work he had observed the weather. He became familiar with the movements of storms and the changes of the clouds. He recorded the barometric pressure at Milwaukee for many years, and from the record of observations on the level of the lake made every three hours, day and night, during August, 1849, he ascertained and published the fact that there is a slight daily lunar tide in lake Michigan, a fact which was fully established later by the record of the self-registering tide gauge, and still better by the United States engineer corps.* (See Report of the Secretary of War for 1861.) He fully believed that storms could be foretold. The desirableness of such predictions was most apparent. The disasters that resulted from the sudden outbreaks of storms from the west were brought home vividly to all who resided on the western shore of lake Michigan. He corresponded with Dr. Caswell, of Providence, R. I., with Cleveland Abbe, of Cincinnati, and Dr. Asa Horr, of Dubuque, Iowa, in connection with whom he carried on a miniature "weather bureau," each aiding the other in determining the course of storms for his locality. He labored in vain for several years. His correspondence with insurance companies and boards of trade and his appeals through the daily press to the general public served only to keep the matter in agitation. He finally made a direct application to Congressman H. E. Paine, from Wisconsin. This memorial calls attention to some predictions of on-coming storms which had been made by the astronomer Le Verrier, as reported by the president of the Toulon Chamber of Commerce in 1863, and to the attempts of Capt. Fitz Roy in England. He lays down the groundwork for a scheme of governmental weather service in the United States, based on the ascertained direction of movement of the great storms of the country, which is that which at the present time is in effective execution. A similar appeal was made by Lapham to the National Board of Trade, through Hon. E. D. Holton, of Milwaukee, who presented it, with a resolution, addressed to Congress, at the meeting of that Board at Richmond, Va., in 1870. It was ably supported by Gen. Walbridge, of New York. It was unanimously adopted, and was immediately forwarded by Mr. Holton to Representative Paine, at Washington. In an "incredibly short space of time for that august body it was passed, in the course, I think, of three weeks; the Signal Service [weather bureau] was thus incorporated."* While the chief Signal Officer, at Washington, had general charge of this new bureau, Dr. Lapham was appointed as his assistant with office at Chicago. It was his duty to receive and summarize reports of the weather from more western stations and telegraph his conclusions to Washington for the benefit of eastern shipping and agricultural interests. It was thus that the first official storm prediction in the United States was sent out by him from Chicago, Nov. 8, 1870, as follows:

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*Col. J. D. Graham, U. S. Engineers, made the same discovery at Chicago ten years later. Message and documents, 1861-62, pp. 404-5.

To observers along the lakes (*bulletin this at once*):

NOON, CHICAGO, Nov. 8, 1870.—A high wind all day yesterday at Cheyenne and Omaha. A very high wind reported this morning at Omaha. Barometer falling, with high wind at Chicago and Milwaukee to-day. Barometer falling and thermometer rising at Chicago, Detroit, Toledo, Cleveland, Buffalo and Rochester. High winds probable along the lakes.

The result verified the prediction. High winds were reported the next morning at the following lake ports: Milwau-

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*Speech of Hon. E. D. Holton, *Insurance Monitor*, Vol. 23, p. 330 (Sherman). The memorial of Lapham to Congress is published by the 41st Congress, Second Session, Dec. 14, 1869, Misc. Docs. No. 10.

kee, Detroit, Toledo, Buffalo and Oswego. Very high winds at Duluth, Chicago and Cleveland.

Dr. Lapham held the position of assistant to the Chief Signal officer until he was appointed State Geologist of Wisconsin, but continued his interest in the work, and contributed as in previous years, the list of disasters upon the lakes until his death, Sept. 14, 1875.

Dr. Lapham's agency in the origination of the Weather Bureau of the Government was endorsed by Prof. Joseph Henry in the following letter to Dr. P. R. Hoy:*

Smithsonian Institution, Washington, Feb. 3, 1876.

Dr. P. R. Hoy, *Racine, Wis.*

Dear Sir: Your letter was received during a great pressure of business, and I now embrace the first opportunity to give it a reply.

The action of Congress in regard to the signal service was due to the immediate exertions of Mr. Lapham through the member of Congress from his district, general Paine, in setting forth the advantages of the system to the commercial interests of the great lakes.

Yours, very truly,

Joseph Henry, *Secretary.*

Notwithstanding the publicity and the unanimity of assent to this claim of priority, there have been some who have attributed it to Prof. Cleveland Abbe, who received the appointment to the position which was at first tendered to Dr. Lapham, viz: that of aid to Gen. Myer who was the Chief Signal officer at Washington. Dr. Lapham having declined it, for personal reasons, he was made assistant at Chicago, as above stated.

It cannot be denied, however, that several others had conceived the same idea in this country. It had actually been put into practice on a small scale, in 1863, in Europe, though probably at the instigation of Redfield, Loomis and others in this country, who had discussed its principles and methods.† It had also been carried on by the Smithsonian Institution, under the direction of Prof. Joseph Henry, and by Prof. Cleveland Abbe, who, at Cincinnati began a series of systematic "weather bulletins" for the Cincinnati Chamber of Commerce in September, 1869. These bulletins, with predictions for the next twenty-four hours, were based on reports from about thirty observers, many of them the volunteer observers of the Smithsonian Institution. Prof. Abbe states that it had been intended by some of the delegates from Cincinnati to the Richmond meeting of the National Board of Trade to bring the subject before that body, but that their action was anticipated by that of Hon. E. D. Holton, of Milwaukee, who presented a memorial drawn up by Dr. I. A. Lapham. It is plain, therefore, that the idea which had been slumbering and waiting, found public sentiment ripe for the official sanction whenever the proper appliances were used to effect it. As in the case of many other great ideas that finally blossom out suddenly into fruitful actualities, that of weather forecasts was not the sole property of one man, still it can be legitimately claimed for Dr. Lapham, in the first instance, that he had an early share in the brotherhood of practical physicists who entertained the belief in the possibility of foretelling the weather by magnetic telegraph, and, in the second place, that he first successfully brought to bear those influences which induced Congress to approve and to authorize the National Weather Bureau of the United States. He, furthermore, was recognized as its responsible and influential instigator when he was called (Milwaukee Sentinel, Nov. 16, 1870,) to Washington to take charge of it under Gen. Myer, a position which Prof. Abbe was called to in January, 1871.* Prof. Abbe's own statement justifies this, and lays at rest forever any doubt of Dr. Lapham's prior action.

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*Trans. Wis. Acad. Sci., Arts and Letters, vol. III, 1876, p. 234.

†In the *American Journal of Science*, July, 1871, Prof. Abbe gives a historical review of all efforts by earlier meteorologists to inaugurate a system of weather forecasts, and also of his own labors at Cincinnati.

3. *Archeological Work.*

"Dr. Lapham's most elaborate work, the one for which he is best known abroad, is his 'Antiquities of Wisconsin.' At an early day he became much interested in the aboriginal earthworks which abounded along the borders of our crystal lakes, and near the banks of many streams. He was the first to notice that many of these mounds are 'gigantic basso-relievos of men, beasts, birds and reptiles, all wrought with persevering labor, on the surface of the soil.' In 1836 he called attention through the newspapers, to a turtle-shaped mound at

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*Testimony before a Joint Commission, etc., on the scientific work of the Government, 49th Congress, 1st session. Misc. Docs. 82, 1886, p. 247. Compare also pp. 269-273, and 461-465.

Waukesha, and to several other animal effigies at other places.

"As many of these must soon be obliterated by the progress of settlement and cultivation, he carefully surveyed and plotted such as his opportunities permitted. The American Antiquarian Society having proposed to pay his traveling and other necessary expenses, he devoted much time to a systematic and thorough survey of these interesting memorials of a pre-historic race. It was a congenial labor, and he prosecuted it with rare devotion and intelligence.

"The results were published in 1855 by the Smithsonian Institution, in a handsomely printed quarto volume, with 55 plates and nearly 100 wood engravings, all from drawings made by himself. 'Beyond the necessary expenses,' says Prof. Henry, 'he derived and received no other compensation than the scientific enjoyment which the prosecution of the work afforded.'

"This publication secured to Dr. Lapham an honorable rank among men interested in pre-historic studies; it is frequently quoted by Sir John Lubbock in his well-known work on 'Pre-historic Times,' and must always remain a standard of authority and reference on the subject which he has so fully and ably illustrated.

"He found peculiar pleasure in the study of these memorials of a perished race, and one of his last labors was the preparation of a series of bas-relief models of some of the more characteristic mounds, for the Centennial Exposition of 1876."—*S. S. Sherman.*

This publication of the Smithsonian Institution had been preceded by a similar volume on a kindred topic by Messrs. Squier and Davis, relating to the aborginal remains of the Ohio valley. This earlier volume had announced the results of the authors as to the origin of the earthworks of which it treats. They ascribed them to a dynasty earlier than the present Indian, a race which they considered much higher in culture and intelligence than the Indian, but which had probably been exterminated, at least expelled from their abodes, by the incursions of the existing red man. This opinion had received the sanction of many savants and of archeological societies, and its authors had been honored by many testimonials to their sagacity and the fulness of their research. It may be understood, therefore, that it required on the part of Lapham a degree of independent reliance on his own observations and judgment, which is not always possessed by scientists, to arrive at and advocate in his volume, a wide departure from the conclusions of his exemplars and predecessors. In short, he ascribed the mounds which he examined, to the agency of the Indian and his immediate ancestors. He saw no reason to call in the aid of an imaginary race. It is not necessary here to dwell on the merits of this question *pro* nor *con*. It is sufficient to say that the views of Messrs. Squier and Davis continued current in scientific circles until within a few years, to the neglect and discredit of Lapham's work. It is only necessary to add that there is at the present almost a unanimous change of view amongst archeologists and ethnologists in America as to the relation of these remains to the present Indian races, resulting in a complete indorsement of the views of Lapham.

4. Cartographical Work.

Lapham's early education as an apprentice, and especially as a young engineer, served to qualify him for skilful draughting, and to introduce him to the wide experience which he subsequently had in cartography. There is no field of professional work in which may be found a greater number of specimens of his handiwork. Even his earliest maps were executed with scrupulous care, and the nicety of their lining and lettering attests the delicacy of his touch and the patience of his untiring application. There are maps extant, some of them unpublished, of Portsmouth, O. (made before he was seventeen years of age), of the region of the falls of the Ohio, showing New Albany, Clarksville and Jeffersonville, on the north side of the river, and Portland and Louisville on the south side, made in 1828, when assistant engineer to the Louisville and Portland canal. This map possesses great historic value and is herewith reproduced on a reduced scale (plate II). The original scale is 1,600 feet to the inch. The reduction is by one-third the linear dimensions of the original. On his removal to Milwaukee (July 1, 1836), one of his first professional acts was the construction of a map of the city, then a straggling village of 1,200 inhabitants, belonging to the territory of Michigan. The lands were not yet surveyed, all new-comers occupied by right of "squatter sovereignty," all tenure was uncertain and liable to encroachment, and continual dispute prevailed. The map of Lapham bears date 1836. The people instituted a code of laws and registration of claims and of transfers, electing Lapham "register of claims."—for no one could as yet get a title from the government. He served gratuitously. The records of this *pro tempore* office are extant. They show by whom every quarter-section in the city and of the county was entered, also the transfers made prior to the date of the public land sale. "Lapham's certificate," filed with the "Judiciary Committee" was duly accredited as valid in all courts, and in later controversies attendant on the final sale and occupancy under the slow machinery of the United States Government, that certificate was thoroughly respected, and justice was maintained to the original claimants. This early map was reproduced annually for thirty years, each edition recording the yearly growth of what became the chief commercial and industrial city of the State of Wisconsin. To all interested in the real estate of the city Lapham's map and records became a *vade mecum* on all questions of boundaries, names, plats and original titles.

With the influx of immigration he saw the need of a guide to the new comers, and he prepared a map of the entire state, to accompany his sketch of Wisconsin,* first issued in 1844. This was improved and enlarged in 1848, running through six editions, and grew, under his widening acquaintance with the natural features of the state, into a geological map of Wisconsin. As such it was published in 1855, at his own expense, and was reissued with corrections in 1869. This is based chiefly on his own observations, although along the Mississippi valley Owen's surveys had preceded. When the

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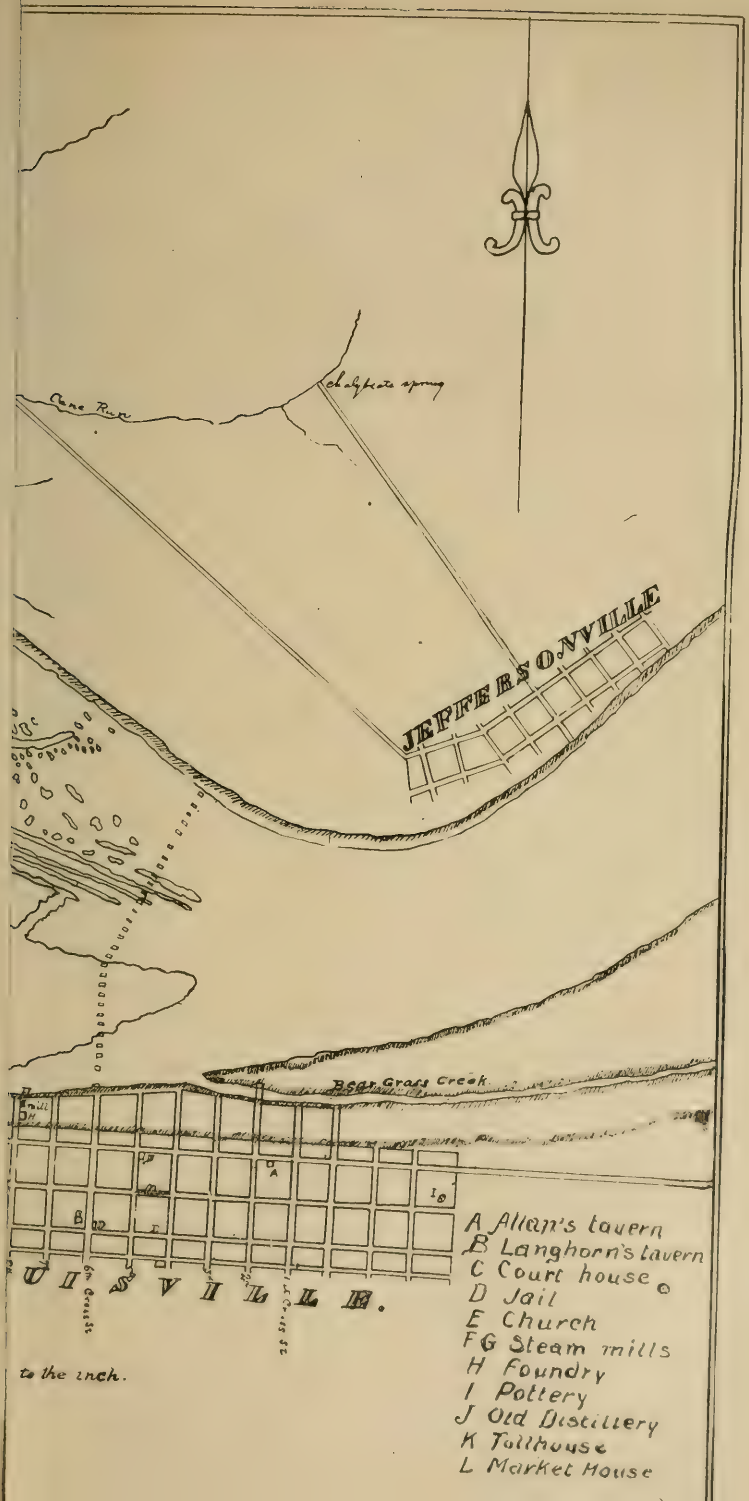
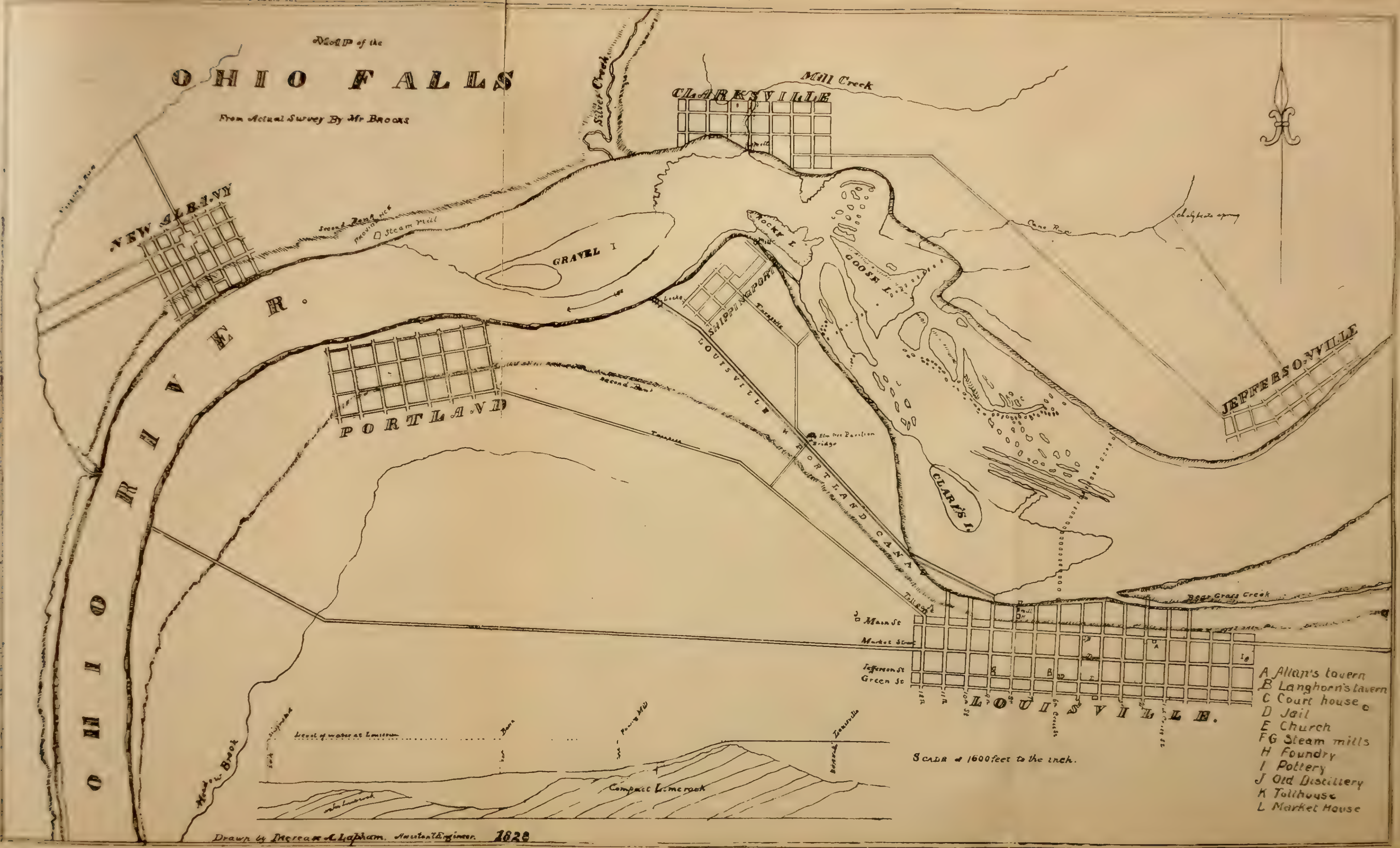
* "Lapham's Wisconsin" is a well-known work among the geologists of the Northwest. Its full title is "A geographical and topographical description of Wisconsin; with brief sketches of its history, geology, mineralogy and natural history, population, soil, productions, government, antiquities, etc." Milwaukee, P. C. Hale, 1844, 255 pp.; second edition, with map, 1846. In 1846 Donald McLeod published a "History of Wisconsan," which was taken almost word for word from Lapham's work published two years before. It also includes his list of plants of Wisconsin, and gives him no credit, in fact does not mention his name. McLeod's publication is still sometimes mentioned as a rare old book.—*Letter of Miss Julia A. Lapham*, Jan. 15, 1891.


Cane Run
chalybeate spring
JEFFERSONVILLE
Bear Grass Creek
UISVILLE.
6th Cross St
Cross St
to the inch.
A Allan's tavern
B Langhorn's tavern
C Court house
D Jail
E Church
F G Steam mills
H Foundry
I Pottery
J Old Distillery
K Tollhouse
L Market House


Map of the
OHIO FALLS
From Actual Survey By Mr Brooks
NEW ALBANY
Silver Creek
CLARKSVILLE
Mill Creek
Second Bank
Steam Mill
GRAVEL I
ROCKY I
GOOSE I
Locks
SHIPPINGPORT
Turnpike
Cane Run
JEFFERSONVILLE
PORTLAND
Second Bank
LOUISVILLE & PORTLAND CANAL
Elm tree Pavilion
Bridge
CLARK'S I
Bear Grass Creek
Main St
Market Street
Jefferson St
Green St
LOUISVILLE.
RIVER
OHIO
Level of water at Louisville
Compact Limerock
Scale of 1600 feet to the inch.
A Allan's tavern
B Langhorn's tavern
C Court house
D Jail
E Church
FG Steam mills
H Foundry
I Pottery
J Old Distillery
K Tollhouse
L Market House
Drawn by Increase A. Lapham. Assistant Engineer. 1828

writer came to Minnesota in 1872, Dr. Lapham sent him this map as a contribution to the geology of the adjoining area, and it hung for many years in a conspicuous place in his office, where it was consulted hundreds of times prior to the publication of the sheets of the great atlas of the late geological survey of that state.

Many other maps, some designed to show the climatology, or the distribution of forests or the statistics, or the location of aboriginal earthworks, or the topography of some portions of the state, appear among his publications. The work of cartographers, in all fields of natural science, and particularly in geology and topography, is apt to be undervalued. It is the function of a map to summarize and express in one view a multitude of details. It is the last conclusion of a long series of tedious and time-consuming records. It is the result of a process of minute research in the confused facts of an untrodden field. It embodies the "Q. E. D." of a philosophical discussion, or of a scientific investigation. It requires a peculiar type of mind to group in the form of an original chart the chief results of such research. We find by this review of Dr. Lapham's work that a resort to the cartographical method of expression was one of his peculiar traits which was frequently resorted to. He was no less a pioneer in this field in the development of the science of Wisconsin, than in others in which he has been more highly applauded.

5. *Geological Work.*

The accompaning list of Dr. Lapham's publications will give in detail his geological work. Beginning in Ohio at the early age of sixteen, when in 1828 he sent his "Notice of the Louisville and Shippingsport canal and of the geology of the vicinity" (with maps, sections, etc.) to the *American Journal of Science*,* he only remitted his geological labors a few months prior to his death, and after he had been honored by the governor of Wisconsin with the appointment of "Chief Geologist" under the law ordering a thorough survey of that state. Twelve of the published works included in the list of his papers are exclusively geological, and several others have geological chapters, or are so allied to or based on a geological foundation that they show a familiarity with geological science. The most of these geological papers relate to Wisconsin. In his first Ohio paper he makes the earliest recorded observation of petroleum filling the cavities in limestone, a fact which was extensively discussed later by Dr. T. Sterry Hunt and by Alex. Winchell, both of these geologists regarding it as indicative of the origin of the large reservoirs of petroleum which have been discovered later.* In his paper on the primitive boulders of Ohio (in conjunction with his brother Darius) he gives facts which show that they increase both in number and in size, from the Ohio river northward as far as the shore of lake Erie, and concludes that they must have had their origin in Canada; and inclines to consider their transportation due to some great flood acting in a southward direction. This was before Agassiz had announced the results of his Alpine studies on glaciers, and was an important original contribution to the geology of the drift. In his paper on certain lacustrine deposits likely to be confounded with the drift, he makes an important distinction between the stratified fine clays, like those from which the cream-colored brick are made at Milwaukee, and the true pebbly and stony drift clays underlying. The finely laminated clays he ascribes to the action of the great lakes when they stood at a higher level. He notes the same clay between Detroit and Ypsilanti, Mich., at which latter point he makes first mention of the ancient lake beach. This distinction has been verified by extended observations about the great lakes. Prof. Chamberlin has carried it much further and ascribes to lacustrine origin some of the pebbly clays which seem to be a phase of the laminated brick clays.

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*Op. cit., vol. v, pp. 65-69, 1828.

"Lapham's Wisconsin," is a duodecimo volume of 208 pages (second edition) and gives a general account of the Territory as then constituted. Wisconsin then contained that part of Minnesota east of the Mississippi river and south of the international boundary as far west as a line running north from the source of the Mississippi. This limitation of its territory and a similar reference to the source of the Mississippi in a definition of the international boundary by the treaty between France and Great Britain in 1763, invested that mythical "source" with such importance that it became the goal of all northwestern explorers, an object of ambition worthy of the most costly and arduous search. Such it has remained almost to the present time. In this general account this territory is divided into four grand districts, viz: 1. The Primitive; 2. The Sandstone; 3. The Mineral; 4. The Limestone districts. The Mineral district is what is now known as the Lead and Zinc district of Wisconsin, in its southwestern portion. The other districts are sufficiently defined in their names. In the description of the limestone district he announces a generalization, based on the general geology, which, as it is not in keeping with some curious facts which he also admits, shows his reliance on the truths of geology. He argues that, as the limestone of the limestone district passes toward the south beneath the coal-bearing rocks of the state of Illinois, and is hence probably the Carboniferous limestone on which those rocks rest in that state, there can be no hope for the existence of coal within the state of Wisconsin. This important generalization, however, was confronted by the following statement which in the light of recent evidence going to show the former existence of the Cretaceous in eastern Wisconsin, is at once a mark of Lapham's sagacity in not allowing it to swerve him from a general truth, and apparently is a further confirmation of the hypothesis of the eastern extension of the Cretaceous over a large area from which it is usually excluded:

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*Hunt. Contributions to the chemical and geological History of Bitumens, and of pyroschists or carbonaceous shales. Am. Jour. Sci., (2) xxxv, p. 157.

> COAL.—Small fragments of coal, associated with bituminous shale, or coal slate, have been found on the shore of Lake Michigan, at Milwaukee and elsewhere; and some indications of coal are said to exist in the vicinity of lake Winnebago.

He also mentions petroleum, and bituminous matter found in the cavities of the eastern limestones in Wisconsin, and cites the reported existence of waterlime in the territory. He gives a list of the minerals known to occur in the territory, and a more or less detailed description of twenty-seven counties.

Dr. Lapham's contribution to the report of Foster and Whitney on the geology of the Lake Superior land district

(1850) was written at the request of Mr. Foster. This is accompanied by two sections showing the succession of strata from Milwaukee to Janesville, and from Grand Haven, in Michigan, to Milwaukee, the latter being designed to show that the basin of the lake is excavated in soft shales and shaly limestones. The sandstone at Janesville, seen in the valley of Rock river, he considers Potsdam. It is overlain by the Calciferous sand rock. In upward succession follow the Blue or Trenton limestone, the Galena limestone, seen at Palmyra and Whitewater, Waukesha limestone, Soft Yellow limestone, Geodiferous limestone, Shaly limestone and Corniferous limestone, the last having a small area at Milwaukee. The section is noticeable for the absence of the St. Peter sandstone. Black bituminous shale found in loose fragments in the vicinity of Milwaukee he attributes to the possible existence of the Marcellus shale in the near vicinity, though nowhere found in place. The design of this article is to demonstrate, according to the general views of Messrs. Foster, Whitney and Hall, that the general stratigraphic sequence seen in New York state can be recognized throughout Wisconsin as in other parts of the Northwest.

In September, 1858, Lapham made one of the first (if not the first) scientific visits and description of the Penokee iron range.* His examination was carried over an extent, east and west, across three townships, and of its location he gives a map, showing towns 44—1, 2 and 3, west of the fourth principal meridian, and T. 45—1 west. This area is in the magnetic portion of the range and is crossed by the Bad river and some of its tributaries. Dr. Lapham describes the general character of the country, the strata which constitute the range and the manner of occurrence of the ore in the rock. He was accompanied by Edward Daniels, one of the Commissioners of the (then) state geological survey. He expresses a very high estimate of the iron-producing qualities of this portion of the range, although he seems not to have seen much, if any, of that soft hematite which has since rendered the Penokee range (in connection with its eastern extension known as the

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*Col. Charles Whittlesey examined this range in 1849. See his description in Owen's report on Wisconsin, Iowa and Minnesota, 1852. p. 444.

Gogebic range) one of the famous iron regions of the country. He based his opinion on some chemical analyses that had been made and on what he saw outcropping, of the hard siliceous magnetite. He fully identifies the ore as passing into the slate rock in one direction and into a "hard rock" in the other, and he concludes that the ore must have had an origin as early as the rock itself. He announces the opinion also that "the geological relations of this prolonged ore-bed are quite the same as those of the non-magnetic ores near Marquette," an opinion which for many years remained current, endorsed as it was by all later surveys, and until the wider extent of this formation was studied in Minnesota.

On the basis of this examination Dr. Lapham wrote two other articles, designed to arouse the interests of capitalists, and the public authority for the construction of the necessary railroads.* But the war of the rebellion soon coming on caused a postponement of material development in northern Wisconsin for many years, and Dr. Lapham did not live to see the fruition of the expectations which he expressed.

On the sudden death of Dr. J. G. Percival, when serving as state geologist of Wisconsin, it was found that his second report was left incomplete and the field notes in much confusion. To Lapham was assigned the task of reducing them to order and preparing the report for the printer. He re-wrote the entire report and added to it a geological map of the state based on his own wider acquaintance with the state, though incorporating also such modifications as the more detailed examinations by Percival made necessary. The report is in substance Percival's, but in form it is more Lapham's.

In 1860, Dr. Lapham made an important announcement to the Milwaukee Geological Club. It was the discovery of "rocks near Milwaukee equivalent to the Devonian (Old Red sandstone) containing remains, which he exhibited, of characteristic fishes. These remains consist of fragments of bone, teeth, and a paddle with portions of the tuberculated skin or osseous covering. The bed containing these remains overlies the Niagara group and is the uppermost of the geological series yet observed in Wisconsin."* The age assigned to this rock was contested by Dr. O. W. Wight in 1875,† but again the judgment of Lapham has been vindicated, in the discovery of many Hamilton species in the vicinity of Milwaukee, in addition to the fish remains first noted. At a later date, July, 1874, Dr. Lapham compared this rock with the water-limestones of Louisville, Ky.,‡ with a suggestion as to its possessing the same useful qualities. This suggestion has also been verified, the average tensile strength of the Milwaukee cement, at the end of seven days, being, according to Gen. Q. A. Gilmore, 64$\frac{1}{9}$ pounds to the square inch, and that of the standard brands of five of the Rosendale companies being 47 pounds.

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*Transactions, Wisconsin Agricultural Society, 1860; and Hunt's Merchant's Magazine, for April, 1860.

The principal event connected with Dr. Lapham's life, having a geological bearing, was his appointment as "chief geologist" of the state survey, ordered in 1873 by the Legislature of Wisconsin. He served about two years and rendered two reports of progress. These are published in the second volume of the final report of this survey, recently concluded under Prof. T. C. Chamberlin. These reports, while not containing much original matter that can be referred to Dr. Lapham's direct agency, yet reveal at once the broad grasp which he had taken of the contemplated work and the efficient executive management and practical turn which his conduct of the survey would have imprinted on its progress and its results. His report for 1873 summarizes the work of the year. His aids were Profs. R. D. Irving, T. C. Chamberlin and W. W. Daniells, and Mr. Moses Strong. The work of each is epitomized in clear, concise language. He then adds a long list of railroad levels, a catalogue of the known minerals of the state, gives many analyses of mineral waters, and tables of the annual rain-fall at Milwaukee from 1841 to 1873, from records mostly kept by himself, the grand average being 30.27 inches. He treats briefly of the relations of the survey to the United States Coast and Geodetic Survey, and to agriculture. It was through his initiatory recommendation that the Coast and Geodetic Survey began the triangulation for the determination of latitude and longitude at various important points in the state, this work being placed under the direction of Prof. J. E. Davies, of the University of Wisconsin. Subsequently a triangulation was extended across the state to the Mississippi valley, under the law of Congress granting aid, through the Coast Survey, to such States as were carrying on either geological or topographical surveys; and this more recently has furnished a basis for the extension of similar work in Minnesota.

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*Am. Jour. Sci., (2) XXIX, p. 145.

†Geology of Wisconsin, vol. II, p. 79.

‡Walling's Atlas of Wisconsin, article Geology, July, 1874.

His second report is similar in scope and contents to his first. It shows, however, a greater amount of detail of geological facts, and indicates that the survey was deeply involved in an investigation of those questions which were at a later date elucidated in full in the reports of that survey. The work of these two years gives a stamp to all the volumes of the final report. The men he employed and the plans he laid perpetuated their influence to the end of the survey. The second year he secured the services of Maj. T. B. Brooks who had but recently concluded his survey of the iron regions of Michigan. The voluminous annual reports of his assistants for 1873 and 1874 are not printed in connection with the reports of Lapham, as they should be in full justice to Lapham, but they were returned to their authors who condensed and corrected them, and incorporated their contents in the final report that was published under the direction of Prof. Chamberlin.

Dr. Lapham gave, in 1874, an epitome of the geology of the state of Wisconsin, in a chapter in Walling's folio atlas (pp. 16-19). The Laurentian he makes the parallel of the term Archean. The Huronian he describes in the same sense as the Michigan and Canadian geologists—*i. e.*, it includes the crystalline and the chloritic schists, the greenstones, the iron-bearing rocks and the quartzites, such as those of Barron county, the base being supposed to be non-conformable upon the granitic rocks of the Laurentian. No limestone was then known in the Archean [here probably meaning to include Huronian in this term] in the state of Wisconsin. Following the Huronian come the copper-bearing rocks. These he makes pre-Silurian. In the section showing the position of the strata from lake Michigan to lake Superior, he represents the rocks of the Penokee iron ridge as dipping northward, but rising again before reaching lake Superior, their northern outcropping edges being hid by the horizontal sandstones. The St. Croix sandstone is described under the name Potsdam sandstone. The Lower Magnesian limestone he considered the equivalent of the Calciferous sandstone of New York. The St. Peter's sandstone has a thickness of about 100 feet, but is "concealed by overlying rocks" to the eastward of its line of outcrop, its most northern known outcrop being in Shawano county. The Buff and Blue limestones (with the Galena) he puts in the Trenton period, and conformable on the St. Peter sandstone. The interesting remark is made that these beds embrace a "layer of highly bituminous shaly limestone, often so well saturated with bitumen as to burn with a blaze." This fact was discovered in Minnesota about the same time, and it shows, as remarked by Lapham, an abundant display of low forms of plant-life over a wide continental area in Lower Silurian time.* The Galena limestone, the Cincinnati group, the Clinton and the Niagara are mentioned. He also adds here, to the Upper Silurian the Racine limestone and the Salina, the latter occurring at a single locality on Mud creek, near Milwaukee; but fragments found in the drift indicate a much greater extent of this rock. It had been the source of small quantities of gypsum and of salt. Of the Devonian he adds to previous statements, the "Black Shale," which is found in considerable quantities distributed in the drift northward from Milwaukee.

His brief paper in 1874, on the relation of the Wisconsin geological survey to agriculture, contains a concise statement of those ways in which geology bears directly on the interests of the farmer, and is designed to recommend the new survey to the favorable attention of such legislators as were from the rural districts. It was read before the State Agricultural Society. The distribution and nature of the drift which determines the distribution and nature of the subsoils, the ascertainment of hights and depressions, on which depend the surface drainage and the depths to subterranean streams, and hence the possibility of artesian wells, the educational incentives that will accrue to the schools of agriculture from a study of the geological structure of the state—these are briefly mentioned.

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*It is apparently the same as the stratum described by J. D. Whitney as Utica slate in Iowa. Geology of Iowa, Vol. I, pp. 359-60, 1858.

In the midst of this energetic and harmonious prosecution of the survey, whose very quietness had attracted the public attention, a disgraceful transaction was perpetrated by the politicians of Wisconsin. The so-called "Granger party" had elected to the governorship a man whose chief aim seemed to be to undo as much as possible of what had been done by his predecessors in office. Gov. C. C. Washburn, founder of Washburn Observatory at Madison and of several benevolent institutions of the State, had received the hearty approval of everyone when he nominated and commissioned Dr. Lapham as chief geologist. This was after the legislature of 1873 had adjourned. This transaction is succinctly stated in the words of Dr. O. W. Wight:[*]

"The commission of the undersigned bears date February 16, 1875. His predecessor was appointed by Gov. Washburn in the spring of 1873, after the adjournment of the Legislature. His name was not sent to the senate for confirmation during the session of the subsequent Legislature. It was, therefore, decided (so the undersigned is informed) by the judiciary committee of the Senate, in the early part of the session of the last Legislature, that the office of the Chief Geologist was vacant. His Excellency, Gov. Wm. R. Taylor, did the undersigned the honor to send in his name to the Senate, and the Senate confirmed the appointment with singular unanimity."[†]

Near the middle of February Dr. Lapham learned from the newspapers that he had been superseded by the nomination of another man. It was nearly a month later when he received the following official communication from Gov. Taylor:

Madison, March 10, 1875.

Dr. I. A. Lapham, Milwaukee, Wis.

Dear Sir:—You are hereby notified that, by reason of the non-confirmation, by the Senate, of your appointment as Chief Geologist, and by reason of the nomination and confirmation by the Senate, and the appointment of Dr. O. W. Wight, of Milwaukee, as Chief Geologist, pursuant to Chapter 292, of the laws of 1873, all authority (if any) possessed by you as Chief Geologist ceased and was annulled on the 16th day of February, A. D. 1875.

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[*] Geology of Wisconsin, vol. II, p. 71.

[†] It has been stated by some biographers of Lapham that his nomination was not confirmed by the Senate; and by others that the Senate "refused to confirm" the nomination. It appears, however, that the Senate never had his name before it for confirmation. It is plain that the responsibility of this underhanded transaction rests solely with Gov. Taylor.

Very respectfully your obedient servant,

W. R. TAYLOR, *Governor.*

This change took the community by sudden surprise. The new appointee had not been known as a geologist, nor has he since. It was palpably a political appointment, and as such it lies at the door of Gov. Taylor. Though geological science in America has suffered numerous such crimes at the hands of politicians, none have been so cruel, causeless and criminal as the removal of Dr. Lapham. There had not been a ripple of discontent. The survey had done an unwonted amount of work considering its means and men. Its reports had been prompt and full. Its maps, sections, sketches, its specimens collected, its scientific and practical results, though still unpublished, and the unruffled harmony that pervaded the corps, all demanded of the executive of the State that its organization should be undisturbed. United with the chagrin of removal was the added sting, which rankled in Lapham's breast until death relieved him, expressed in Gov. Taylor's official letter, of *non-confirmation* by the Senate. This was a fact, and at the same time a misrepresentation; but the wiliness of the artful politician, as revealed by the statement of Dr. Wight, is apparent in the governor's silence as to the cause of non-confirmation,—his name had never been presented to the Senate. It had simply been an oversight on the part of governor Washburn. He held Gov. Washburn's commission. He was no politician. With him official position was never sought, but came unsolicited. He was not a self-confident man. He was modest and never ambitious of personal preferment. He had spent much of his life in gratuitous service of the State and of the community in which he lived. He had a right to expect that the only remunerative public position which he ever held would be allowed to continue until he could bring to a successful close those long continued labors on its natural history and its industrial resources which he had prosecuted hitherto unrewarded. He had a right to hope that he would be able to establish, in the completion of this survey, a commemorative and creditable monument to his zeal and industry, which succeeding generations would not willingly forget. Under the circumstances there appears not one palliative streak of justification or excuse for the cruel act of governor Taylor. It was an extreme exemplification of the unreason and selfishness of partisan politics. The press and the public generally considered his removal under the circumstances an unpardonable outrage. It is a lesson, however, which, with others that geology has learned from similar source, speaks loudly for redress, and which warns geologists that partisan politics is a ravenous creature which respects no persons, no services, no public weal, or personal rights, and which prostitutes to its own uses the non-partisan labors of the scientist, as relentlessly as the wolf devours the lamb.

Dr. Lapham's assistants tendered their resignation and sent to Dr. Lapham the following letter:

I. A. Lapham, L. L. D.

Dear Sir:—We trust that the intercourse of the last two years, during which we have acted as members of the geological corps under your direction, has not left you without unmistakable evidences of the confidence we have reposed in you as a man, a scientist and as our official superior; and we hope that, even now, it is not necessary that we should add to these evidences. But we, nevertheless, desire to express individually, and collectively, and in this explicit manner, our high appreciation cf the very great efficiency of your administration of the survey and of the valuable assistance you have rendered us in the discharge of our duties; of the many facilities you have placed in our possession, which have added largely to the work accomplished; of that vast fund of knowledge collected by your industry, during thirty years, or more, of active study of the resources of the state, which has ever been freely at our command, and which has been so generously mingled with our own accumulations; of that promptness which has never caused a delay for want of material, or instruction; of that exactness which has never left room for hesitancy or doubt, and of that prudence and discretion that have so conspicuously marked your administration. More than we can readily estimate of those results that bear our names, are due to the contributions that you have continually poured into them.

Knowing that time, which proves all things, will do ample justice, and feeling most strongly the irreparable loss the State has sustained in the disseverment of your connection with the survey, we remain, with most sincere respect, your obedient servants,

Roland D. Irving,
T. C. Chamberlin,
Moses Strong,
Assistant Geologists.
W. W. Daniells,
Chemist to the Survey.

The rest of the story of Lapham's life is quickly told. He must have received the injury that was done him as a mortal blow. It had fallen unexpectedly, sharply and heavily. In the retirement of his family he may have revealed the poignancy of his wound, but he never publicly complained. His loyal, trusting heart, which had suspected no enemy, was broken by the ingratitude and injustice of the State which he had served. He retired temporarily to his son's farm at Oconomowoc. The modesty and fortitude of the Quaker training to which he was born and in which he lived and died, did not forsake him. He busied himself for a few months with some of the problems that were connected with the lake near which his residence was situated. Another summer season rolled by. The autumn came. With declining health he seeks recreation and at the same time information in the examination of the soundings, temperature and currents of the lake. His boat is his sole companion. The lake is calm and beautiful. A September quiet pervaded the hour. The fading hues of the surrounding foliage are a sweet reflection of his life's mellow autumn. The sun's last evening rays did not see him return. The shades of a beautiful life close about him, and he surrenders up in silence and alone, the gentle spirit which had become weary of the jostle and insincerity of man.

5. *Miscellaneous Papers.*

But we must return to a further consideration of some of Lapham's work. He was many-sided. To do him justice requires at least a brief mention of other public contributions. He was active in the first movements which resulted in the establishment of several of the present institutions of the State, both educational and scientific. Indeed there was scarcely any important enterprise which affected the general weal of the community or the State, with which he was not connected. In 1846 he donated to the city of Milwaukee thirteen acres of land for the purposes of a high school, and when it was by neglect allowed to lapse for non-record of deed and non-payment of taxes, and was sold, he redeemed it and renewed the deed. He was one of the founders of the Milwaukee Female College, and served for many years as president of its Board of Trustees. He assisted in the organization of the Young Men's Association. He was the first and most liberal contributor to the cabinet of the State University. He was one of the founders of the Wisconsin Historical Society, and of the Wisconsin Academy of Sciences, Letters and Arts. He was one of the original members of the American Ethnological Society, an active member of the American Association for the Advancement of Science, an honorary member of the Royal Society of Northern Antiquarians of Copenhagen, a member of the American Philosophical Society, and of most of the Scientific and Historical Associations of the United States. In 1860 Amherst College (Mass.) conferred on him the degree of Doctor of Laws.

The Doerflinger meteorite, often known also as the Wisconsin meteorite, was brought to light largely through his agency. A farmer brought a sixteen-pound piece to the city from a locality about thirty miles northwest from the city of Milwaukee, and found his way to a hardware store, where Mr. Doerflinger was struck by the peculiar appearance of the iron. On applying the proper acid to a roughly polished surface he was gratified to see the appearance of beautiful Widmannstattian figures. Mr. Doerflinger reported the facts to the Natural History Society and presented the piece to the society. Two smaller pieces were acquired subsequently and a full account of the occurrence was printed.

"At this time Dr. Lapham first heard of the find, and in consideration of his many valuable services to the Natural History Society the Board of Directors resolved to present him with a piece not to exceed two pounds in weight.* * * Dr. Lapham had been informed exactly of the location of the farm, and although on his first visit the farmer would under no conditions part with his property, still Dr. Lapham succeeded, by the aid of his well-known amiability, persistency and a considerable roll of greenbacks, in softening the farmer's heart." It was the wide distribution among scientists made at once by Lapham, that brought this meteorite to notice in scientific publications. In examining a polished piece returned to him by Dr. J. Lawrence Smith, he noticed certain peculiar markings developed within the Widmannstattian figures and called Dr. Smith's attention to them. The latter gave the first description of these smaller figures in the American Journal of Science* with a figure, and proposed to name them Laphamite markings. These peculiar figures are portions of the area in general marked by the Widmannstattian lines, and instead of having their extremities rounded like the Widmannstattian lines, they have rectangular or concave extremities. These areas are marked by a much finer lining, indicating, as thought by Smith, the axes of minute columnar crystals produced by cooling on contacting with a cold surface, and this proving that the Laphamite-marked area was of later origin and molten when the Widmannstattian area was solid. A few years later Dr. Smith noted the same fine lining on a meteoric iron that had been preserved in the cabinet of the late Prof. Troost, and says: "In connection with these Widmannstattian figures I will call attention to the delicate parallel lines inside these figures, which I pointed out several years ago as being peculiar to certain of the irons, and which I designated by the term Laphamite markings."† Dr. Lapham prepared an elaborate list of all known American meteorites, with citations of authorities, but it was never published, so far as known. Dr. C. U. Shepard urged him to submit it to the American Journal of Science. The Laphamite markings are also illustrated in the American Encyclopedia (New Ed.) under the article "Aerolite." Somewhat later Dr. Lapham gave particulars of the discovery of additional fragments of the Wisconsin meteorite, making a total of 143 pounds. The six fragments were all found in the same field in the town of Trenton, Washington Co., about 30 miles northwest from Milwaukee.‡

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*Records of the Natural History Society, Dec. 7, 1868.

Although Dr. Lapham did not publish much that could be called zoological, yet among his papers are several manuscripts wholly zoological. One is a "Catalogue of the Fishes of Wisconsin and the adjoining states; with a synopsis of the families, references to the places where they are figured and described, etc., etc.," prepared in 1860. This synopsis is a sort of analytical key, like that of Dr. Asa Gray, published in his Manual of Botany, by which a student can trace out and determine the name of any certain fish. The second part is a list of all known fishes in the waters of the states northwest of the Ohio river to and including Minnesota. This was no collation simply, but at the time he prepared it (between 1850 and 1860) he was in correspondence with Dr. Kirtland in regard to the fishes of Ohio and Wisconsin, and it embraces much original observation. Among his papers are twenty-seven packages of fish-scales with notes of the peculiarities of different species, and outline drawings on rough paper where the fishes were laid on the paper and drawn from nature, as the paper shows. This was long before the Fish Commission of Wisconsin was organized; and it is probable that his interest in fishes aroused by this study led him to suggest, as he did in a letter to Hon. F. G. Parker, then in the Wisconsin Legislature, the appropriation of a sum of money "for the propagation and introduction of better kinds of fish." In reply, Mr. Parker asked him (Jan. 21, 1873) to draft a bill and send him for introduction in the Assembly, saying that he thought an appropriation of $500.00 would be allowed when the proposition should be understood.

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*Op. cit. (2), XLVII, 271, 1869.

†Op. cit. November, 1875.

‡Amer. Jour. Sci. (3), III, 69.

He made large contributions to the laboratories of Isaac Lea and Dr. S. P. Hildreth, of shells from Ohio, and the latter found material for several new species among the specimens sent him. He prepared, in 1834, a "List of American Shells," which still remains unpublished. In 1875 he prepared another of the shells of Wisconsin. Following is a list of his most important unpublished papers, prepared by Miss Julia A. Lapham:

LIST OF UNPUBLISHED PAPERS OF DR I. A. LAPHAM.

Prepared by Julia A. Lapham.

1832. *Indian Antiquities of Portsmouth, O.* Consists of sketches of arrow points, extracts from letters and journal, etc., etc., evidently intended as material for an article, but I am quite sure it was not published.

1833. *On boring for fresh water.* May have been published in some newspaper.

1831-36. Notes of the time of showing buds, leaving out, blossoming, fruit, and shedding leaves of all trees and shrubs in the localities he happened to be in.

1834. *List of American shells.* Was evidently prepared for exchanging specimens, possibly with an idea of publishing sometime. There is a great deal of work in it, done with and for judge Benjamin Tappan and Dr. S. P. Hildreth, with a criticism of Conrad's table of American *Naiades*, suggesting many alterations. I do not know whether they met with favor.

1836. *Change of level of lake Erie*, and *Rise and fall of lake Michigan.* I still cannot satisfy myself in regard to these two papers. They evidently were ready for publication, and may have been in some newspaper, as he frequently wrote for the *Sentinel.* There was however, no paper in Milwaukee at that time.

1840. *A week in Wisconsin. Its animals, plants and mounds.* This *was probably* published in the *Sentinel*, but there is nothing to show it. On nearly all his trips through the state and elsewhere, he wrote letters to the Milwaukee papers. One series was headed "Glances at the Interior."

1849. *Geological Notes: Tour to the Dells.* May have been published as above.

1851. Geology of Wisconsin. We have the manuscript.

[There is a paper by Dr. Lapham on the "Geological formation of Wisconsin," in Trans. Wis. State Agl. Soc., Vol. I, 1851, written about this date, but as Miss Lapham states that this unpublished article is illustrated, it is doubtful whether they are the same. One figure is designed to show the Wisconsin geological column, beginning with the "Primitive" and ending with the Devonian, the last surmounted by the drift, lake deposits and the soil. The thickness of each formation is expressed in feet, the sedimentary rocks and drift amounting to 1950 feet. Another figure, supposed to belong to this unpublished article, is "a section showing the equivalence of the Marquette and Menominee iron deposits, by Prof. Raphael Pumpelly," but it is apparently misdated and out of place. N. H. W.]

1836-71. Meteorological manuscript. Some of this has been published, but a great deal of it has not.

1853. *American Paleontology.* There is a great deal of work done here, and I send you the agreement between father and Prof. Hall. Why it was not carried out I do not know. Evidently father did his part of the work.

[The agreement referred to by Miss Lapham is as follows, in Lapham's hand:

This agreement, made this first day of March, A. D. 1853, by and between James Hall, of Albany, A. [N.] York, and I. A. Lapham, of Milwaukee, Wisconsin, witnesseth: That said Hall agrees to prepare a work to be called *American paleontology, et cetera*, based upon manuscripts now placed in his hands by said Lapham (which manuscript embraces descriptions of about two thousand species) and to procure the publication thereof upon the most favorable terms, as the joint work of said Hall and Lapham; that in case no publisher is found to assume the expense of the publication, then the work is to be published at the joint and equal expense of the said parties hereunto; that said work and publication is to be completed within one year from the date hereof, and that all proceeds and profits resulting from the said publication are to be divided equally between the parties aforesaid.

Witness our hands, our hands on the day and year first above written.

In presence of }
F. B. Meek. }
JAMES HALL,
I. A. LAPHAM.

—N. H. W.]

After 1853. *Antiquities of Wisconsin.* Consists only of notes, sketches, etc., partially for a new edition which he would like to have published.

1854 to 1860. *List of North American Meteorites.* We have this manuscript.

1856. Catalogue of the described Gramineæ of the United States. Ten plates of drawings. We have this manuscript.

1858-59. *List of the mosses of Wisconsin.*

1858. *The Red river of the North, with an account of the rich and fertile country along its banks in Minnesota and Dacotah,* with illustrations and a map. A large manuscript ready for publication.

[Important as a historical document for the State of Minnesota.—N. H. W.]

1860. Catalogue of the Fishes of Wisconsin and the adjacent states, with a synopsis of the families, references to places where they are figured and described, etc.

1860. *On wind.* We have the manuscript.

1860-1875. Letters, notes and manuscript, merely prepared for future use, Lake and Coast survey.

1861-63. *List of the mosses of Wisconsin,* with Index.

1865. *Report of the geology of Council Hill, Ill., Lead mines.* Made for Messrs. Gregory and Hilton, with profiles, maps and drawings.

1861. *Milwaukee county.* This was written for the Wisconsin Agricultural Society, but was not published, as the Board were not willing to pay for it.

1865. *On general atmospheric movements.*

1868-69. *On building-stone.* All, or nearly all, published in the Milwaukee papers, when the court house was planned.

1868-69. *Account of Sauk county.* Its general history, geology, botany, etc.

1869. Aug. 7. *Solar eclipse.* This consists of observations on the eclipse, and meteorological observations during the time.

1871. *Geology of Georgia. A sketch of a trip to Stone Mountain.* Written after making the trip.

1875. *On the Cranberry, acid of, etc.*

[This subject, in connection with Lapham's study, was referred to in a late number of the *Wisconsin Weather and Crop Journal*, Vol. II, No. 4, p. 6, April, 1893.—N. H. W.]

1875. *List of the shells of Wisconsin.* Additions to the early list of 1836.

[Of this manuscript Dr. P. R. Hoy says: "What a pity your father couldn't finish the book. It would have been a capital volume; and the drawings were so good and exact. I knew the doctor was exact with the pencil, but I was not prepared for so fine and good work."]

There are many testimonials to the personal character of Dr. Lapham. They all ascribe to him an unimpeachable integrity in business, and a blameless transparency in all his social and domestic relations. He was as free and honest as the sunlight, and his presence and willing dedication of his whole energy to the service of the little group at home, or to his scientific friends when they called on him, made him the almoner of gracious influences. He lived more for the service of others than for himself. Disappointments, injustice inflicted upon him through either political or personal motives, left him outwardly unscarred, because he harbored neither ambition nor resentment. His griefs rose more from his own inability to accomplish his beneficent purposes than from the failures of any personal ambitions. The genial hospitality of his home, where the appreciative aid of a loving wife and family surrounded him, embraced all visitors and rendered them more than welcome.

Dr. Lapham was modest, patient, industrious, unwilling to appear in public, but ready to act as a private wherever his services were needed, one of the few who seek in their own labor their chief reward, one of the true noblemen of nature. His name will always cast an honor on the State of Wisconsin.

He married Ann Maria Allcott, whose father was a second cousin of A. Bronson Allcott. He left five children, three sons, Henry, Seneca George and Charles, and two daughters, Mary J. and Julia Allcott.

The value of Lapham's services to Wisconsin will grow in the estimation of competent judges as time passes by. When we are near the light we are not so able to judge of its brightness as when we are so far removed that we can compare it with other lights or with surrounding objects. In the distant future Lapham's name will appear brighter in Wisconsin because of its shining almost alone and in an epoch when such lights were few, and generally faint. The effort to honor Lapham's name was well begun by the generous offer and the prompt responses mentioned at the opening of this sketch. That should not be the end of that suggestion. The State would honor herself by recognizing Lapham's merits in some substantial and permanent manner. The United States Weather Bureau cannot allow his name to be forgotten. "He is the guardian genius of our lake commerce, and on that crimson flag which so often flutters in the rising breeze, the herald of the coming storm, should be inscribed—LAPHAM!"

[NOTE. Besides the biographical sketches that are mentioned at the opening of this sketch, the following notices have appeared: Popular Science Monthly, April, 1883, pp. 835-840, sketch by the editor, based on

Sherman's address, with a portrait. Appleton's Cyclopedia of American Biography, a sketch based largely, or entirely, on Sherman's address. Dr. P. R. Hoy and Mr. E. R. Leland have tributes to the life and labors of Lapham in Vol. III of the Transactions of the Wisconsin Academy of Sciences, Arts and Letters. Proceedings of the Davenport Academy of Natural Sciences. Vol. II, 1876-77; sketch by Dr. C. C. Parry. The American Antiquarian, March, 1893; short sketch by the editor, with a portrait. The following bibliography is taken primarily from the lately published "Bibliography of Wisconsin Authors," prepared and published by the Wisconsin Historical Society, but it contains some corrections and additions.]

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1. Notice of the Louisville and Shippingsport canal and of the geology of the vicinity. (With plates, sections, etc.)—Am. Jour. of Sci., (1) XIV, pp. 65-69, 1828.

2. Observations of the primitive and other boulders of Ohio, by Darius and Increase A. Lapham.—Id., (1) XXII, pp. 300-303, 1832.

3. Miscellaneous observations on the geology of Ohio.--State Documents of Ohio, p. 31, 1837.

4. On the existence of certain lacustrine deposits in the vicinity of the great lakes, usually confounded with the "drift."—American Journal of Science, (1) XXXII, pp. 90-94, 1837.

5. Catalogue of plants found in the vicinity of Milwaukee, Wisconsin Territory. Milwaukee, 23 pp., 1838.

6. Documentary history of the Milwaukee and Rock River canal. Milwaukee, 151 pp., 1840.

7. Report on the commerce of the town of Milwaukee, and navigation of Lake Michigan. 1842. (Pamphlet.)

8. A geographical and topographical description of Wisconsin, with brief sketches of its history, geology, mineralogy, natural history, population, soil, productions, government, antiquities, etc., etc. Milwaukee: P. C. Hale, 1844, 255 pp.; 2d ed., improved, with map, 208 pp., 1846.

9. Statement of elevation of Wisconsin.—American Journal of Science, (1) XLVI, pp. 258-260, 1844.

10. Communication to Governor Dewey on the subject of a state penitentiary.—Journal of Wisconsin Assembly, pp. 682-687, 1849.

11. (Catalogue of) Plants of Wisconsin.—Proceedings of American Association for the Advancement of Science, pp. 19-62, 1849.

12. Wisconsin; her topographical features, and general adaptation for agriculture.—Northwestern Journal of Education, Science and General Literature, I, pp. 46-49, 1850.

13. Meteorology.—Ibid., pp. 117-122.

14. On the geology of the southeastern portion of the state of Wisconsin, being the part not surveyed by the United States geologists.—Report on the Geology of the Lake Superior land district, by J. W. Foster and J. D. Whitney, Part 2. Washington, pp. 167-173, 1851.

15. Communication in regard to state cabinet.—Meteorological Department, etc. (Pamphlet), November, 1851.

16. Geological formation of Wisconsin.—Transactions, Wisconsin State Agricultural Society, I, pp. 122-128, 1851.

17. A systematic catalogue of the animals of Wisconsin, prepared for the use of the University of Wisconsin.—Fourth Annual Report, Board of Regents of the University of Wisconsin, pp. 43-56, 1851.

18. Meteorological observations made at Milwaukee.—Transactions, Wisconsin State Agricultural Society, I, p. 306, 1851; II, p. 449, 1852. Also in American Almanac, p. 102, 1852.

19. Fauna and flora of Wisconsin.—Transactions, Wisconsin State Agricultural Society, II, pp. 337-419, 1852.

20. The grasses of Wisconsin and adjacent states. Plates.—Id., IV pp. 397-488, 1855.

21. The forest trees of Wisconsin.—Id., IV, pp. 195-251, 1855.

22. The antiquities of Wisconsin as surveyed and described by I. A. Lapham, on behalf of the American antiquarian society. 55 plates. Washington, xii+108 pp.—Smithsonian Contributions to Knowledge, 1855.

23. The native, naturalized and cultivated grasses of the state of Illinois. Plates.—Transactions, Illinois State Agricultural Society, II, pp. 551-609, 1856-57.

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Dr. Lapham was a prolific writer for the press, and for encyclopædic publications. One of his earliest articles was On Farmers' Libraries, in *The American Farmer*, 1832; another on Agriculture in Ohio, in the *Genesee Farmer*, 1833; in the *Milwaukee Sentinel* for Sept. 3, 1849, he had an important article on Discovery of a Tide in Lake Michigan; the article on Wisconsin, in *Appleton's American Encyclopædia* (1859-1862) was by him, written at the request of Governor Haney; in *The Chicago Tribune*, 1873, he wrote on Supposed Subterranean Sources of the Waters of the Great Lakes; in the *Milwaukee Republican*, March 1, 1852, he wrote of The Geology of Waukesha. These are only a few of his important newspaper articles, but show the scope of his work. His map of Milwaukee, first issued in 1845, was published annually until 1861; his map of the state, first issued in 1849, was republished in 1850, 1853, 1854 and 1857. He published a geological map of Wisconsin in 1855 and 1869; and the state map in the Legislative Manuals, 1865-75, was his work.

ON THE MODE OF OCCURRENCE, AND THE STRUCTURE AND DEVELOPMENT OF TRIARTHRUS BECKI.*

By C. E. **Beecher**, New Haven, Conn.

The presence of antennæ and other appendages on a trilobite from the Utica Slate was announced in May, 1893, by W. D. Matthew.† The specimens were discovered by W. S. Valiant,‡ near Rome, New York, where they occur in a fine-grained carbonaceous shale. It was apparent that specimens preserving organs so delicate as antennæ ought to show, in addition, other anatomical features which would be of great assistance in determining the zoölogical position of the *Trilobita*. With this object in view, and with the assistance of Prof. Marsh, a collection was made for the Yale University Museum. From this material, it is hoped that the remaining details in the structure of this important fossil may be made out. The preliminary examination of the specimens shows a number of new and remarkable structural features, some of which will be briefly noticed here. It was also possible for the writer to make observations in the field, which furnish interesting facts as to the mode of occurrence, and to the habits of the trilobite.

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*Abstract of a paper "On the Structure and Development of Trilobites," read before the National Academy of Sciences, November 8, 1893.

†"On Antennæ and other Appendages of Triarthrus Beckii." Read before the N. Y. Academy of Sciences, May, 1893. Published in American Journal of Science, vol. xlvi, pp. 121-125, August, 1893.

‡Mr. Valiant informs me that he found the first specimen showing antennæ in 1884, but it was not until 1892 that other specimens were obtained by him and M. Sid. Mitchell fully establishing the discovery. The specimens sent to Columbia college were collected by W. S. Valiant of Rutgers college.

In their present condition, the specimens contain very little calcite matter, and nearly the entire calcareous and chitinous portions of the animal are represented by a thin film of iron pyrite. To this kind of fossilization is doubtless due the preservation of delicate organs and structures, which otherwise would have been destroyed. For, as is well known, pyrite may replace such organic tissues as chitine or even soft dermal structures, the change occurring by the slow decomposition of these tissues in the presence of iron sulphate in solution, or from the action of hydrogen sulphide as a result of decomposition in a chalybeate water.

From the mode of occurrence of the specimens, it is evident that some physical change of a rather sudden nature must be inferred to explain the facts. This is shown from the following considerations: (1) their restricted vertical distribution; (2) nearly all specimens are complete and preserve their appendages; (3) they are of all ages, from larval forms up to full-grown individuals; (4) the rock has a characteristic structure and composition; and (5) the adjacent strata contain a rather sparse fauna in which the trilobites are generally fragmentary, or usually without appendages.

It does not require a violent catastrophe to account for these peculiarities, and, as in the case of the recent destruction of the tile fish off the eastern coast of the United States, it is possible that a temporary change in the direction of an ocean current, with the consequent variation of temperature, would be amply sufficient. Just what occurred in the present instance has not been determined. Throughout the trilobite-bearing rocks generally, young and larval forms are extremely rare, while, of full-grown examples, fragments are the rule and entire specimens the exception. Therefore, it is believed that the remains commonly found represent sheddings or moults, and not in each case the death of a separate individual. In the present material, however, the almost invariable perfection of the specimens precludes this view. Moreover, the appendages are apparently in the position held in life, and not such as obtain in the cast-off shells of recent crustacea.

Another feature noticed in the field is that the specimens nearly all lie with the back down. The same thing has been observed by other investigators, and has been accounted for by the assumption, that in being drifted about along the bottom, such a position would be assumed from the center of gravity being on the convex side. This idea does not seem tenable, because, while on their backs, the trilobites would be most easily rocked by the currents of water, and eventually be turned over or dismembered. A further explanation has been offered by Hicks and accepted by Walcott,* to the effect that trilobites probably lived with the ventral side down, and the accumulation of gases in the viscera during decomposition was sufficient to overturn the animal and allow it to be buried by the deposition of sediments in the position now found. This theory, also, does not meet the facts as here observed, for in turning over a dead and limp animal provided with long and slender antennæ, delicate jointed legs, and fringed appendages, the legs would be either folded under the carapace on one side, or displaced from their natural position. But, as has been already noticed, the present material generally shows the legs extended on both sides of the body and the antennæ in a very life-like position. (Plate III, figures 3-7.)

It seems most probable that trilobites could both swim freely and crawl along the bottom, and that, on dying, they coiled themselves up in the same manner as the recent isopods. Then upon unrolling they would necessarily lie on their backs. Even if they did not coil up, any swimming animal having a boat-shaped form would settle downward through the water with the concave side up.

The definite structure of the legs of *Triarthrus* is now for the first time clearly shown, and is of much interest. Furthermore a difference can be seen in the appendages of the pygidium, thorax, and cephalon. Those of the çaudal region overlap each other, and are furnished with very long hairs, or setæ. The appendages of the head include the antennæ and the mouth parts, the latter consisting of the mandibles and maxillæ bearing palps and setæ.

The legs of the thorax have been worked out in detail, and

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*The Trilobite: new and old evidence relating to its organization. Bulletin of the Museum of Comparative Zoölogy, vol. viii, No. 10, 1881.

are shown on Plate III, figures 8, 9. No essential differences have been observed in the series attached to the free segments. Each segment bears a pair of biramous appendages, originating at the sides of the axis, as in other trilobites (Walcott, *l. c.*). The anterior legs are the longest and the others gradually become shorter towards the pygidium. Those which are here taken for description are the legs of the second and third free thoracic segments. The entire length of the legs has been exposed from the dorsal side, by removing the overlying pleuræ of the thorax, which concealed nearly half their length. Each limb consists of two nearly equal members, one of which was evidently used for crawling and the other for swimming. These two members and their joints may be correlated with certain typical forms of crustacean legs among the *Schizopoda*, *Cumacêa*, and, *Decapoda*, and may be described in the same terms. Therefore each limb is composed of a stem, or shaft, with an outer branch (exopodite), and an inner branch (endopodite). Plate III, figure 9, shows the joints of the stem (6, 7), the exopodite (*ex*, 1 and 2), and the endopodite (*en*, 1-5). The precise form of the coxal joint of the stem (coxopodite) has not yet been clearly made out. It is followed by a broad joint about twice as long as wide, which may be referred to the protopodite.

The endopodite (figure 9, *en*) was the member used for crawling, as in the *Schizopoda*. The three proximal joints (5, 4, 3) are similar in form to 6, and taper gradually outwards. The distal portion is completed by two slender cylindrical joints (2, 1), the latter bearing at its extremity short setæ, or bristles, of which three are commonly to be seen.

The other member, the exopodite (*ex*), lies over the endopodite. It apparently articulates with the protopodite, but may spring from what is here referred to the coxopodite, as its basal portion is very broad and originates close to the articulation of the protopodite with the coxal joint. The proximal joint of the exopodite (2) is somewhat arched and tapers rapidly. It extends to the ends of the pleuræ, and is the longest joint of either branch. The posterior edge is finely denticulate, and carries a row of long setæ. The distal portion (1) is multiarticulate, being composed of ten or more joints. In general form, it is slightly crescentic, with the margins thickened, the anterior one being strongly crenulated. Long setæ extend posteriorly from the crenulations on the dorsal side of the leg, making a conspicuous fringe along the distal half of the exopodite.

Plate III, figure 7, represents a dorsal view of *Triarthrus Becki*, showing the antennæ and the exposed portions of the appendages. The antennæ and legs on the right side are drawn from one specimen, and the legs on the left side are as shown in another individual. The biramous character of the entire series of thoracic legs is very evident, as is also the distinction between the crawling and swimming members. Figure 8 shows the right second and third legs of the free thoracic segments. In figure 9, the upper exopodite is represented without setæ, so as to bring out the structure in greater detail. On the lower leg, the setæ are shown.

The antennæ are about as long as the head, and are composed of short conical joints. They usually occur in the position shown in figures 5 and 7, but occasionally lie close to the margin, figures 3 and 4, and sometimes curve backwards over the head, as in figure 6.

It is not necessary in this place to describe in detail the development of *Triarthrus Becki*, but attention may be called to two early larval forms. The youngest is shown on Plate III, figure 1, and may be compared with the first segmented stage, figure 2, and with the adult, figure 7. At this early stage, the animal is less than one millimeter in length (.63 mm.), and has no distinct separation into parts. The division into a cephalic and a caudal region is indicated by a transverse groove, but as yet the body segments are undeveloped. After the separation of the head and pygidium, the thoracic segments are introduced successively between the head and abdomen until the full number is reached, and the animal measures from 10 to 55 millimeters in length. The segmented stages have been described fully by Walcott,* and an outline figure of the stage with one thoracic segment is given in figure 2.

The final conclusions to be reached from a complete study of the development and structure of these animals can only as yet be surmised. It is quite evident, however, that they are

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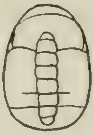
*Transactions Albany Institute, vol. x.



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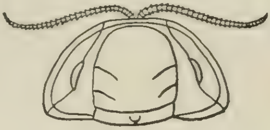

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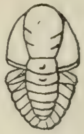

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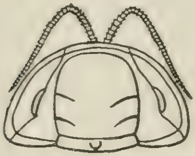

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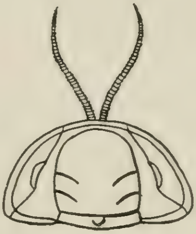

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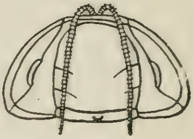

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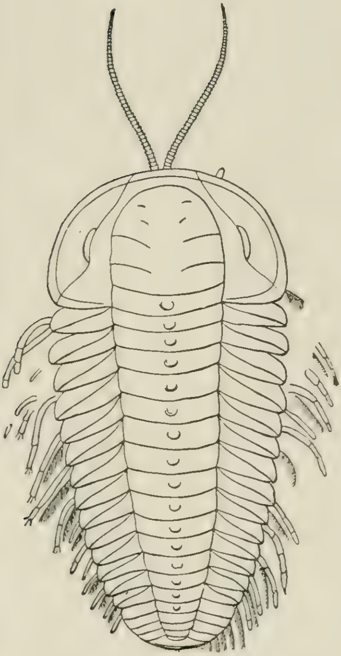

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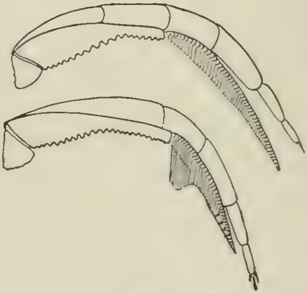

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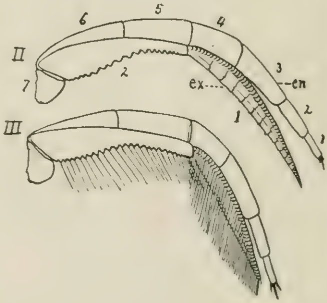

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related to the true *Crustacea*. The *Trilobita* are shown to be a primitive type in (1) their multiple segmentation, (2) the irregular number of thoracic legs, and (3) the biramous structure of the legs. They therefore present characters common to the *Entomostraca* and *Malacostraca*.

EXPLANATION OF PLATE.

TRIARTHRUS BECKI Green.

Figure 1.—Dorsal view of larva, x 28.

Figure 2.—Dorsal view of young individual, with one free thoracic segment. (After Walcott.)

Figure 3.—Cephalon with antennæ nearly at right angles to axis. The thorax and pygidium are omitted in figures 3–6. The figures are enlarged 3–5 diameters.

Figure 4.—Cephalon with antennæ bent outwards and backwards.

Figure 5.—Cephalon with slightly diverging antennæ directed forward —the usual position in the majority of specimens.

Figure 6.—Cephalon with antennæ curving backward between the eyes.

Figure 7.—Dorsal view; showing antennæ and crawling and swimming legs, x 3. The legs on the left side are taken from a smaller specimen and are enlarged 6 diameters.

Figure 8.—Appendages attached to right side of second and third thoracic segments; taken from another specimen.

Figure 9.—The same; with setæ omitted from II, to show details of structure; *ex*, exopodite; *en*, endopodite. The setæ are represented on III, x 12.

FALSE BEDDING IN STRATIFIED DRIFT DEPOSITS.*

By J. E. SPURR, Gloucester, Mass.

The rule has been generally accepted that whenever in stratified deposits persistent layers differing decidedly in structure are found to alternate regularly, then the plane of these layers is to be regarded as the actual plane of deposition, that is, approximately parallel to the surface of the water in which the sedimentation took place. The layers in cross-bedded structure, which are restricted, both as regards thickness and lateral extent, do not, of course, come under this rule.

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*Published by permission of N. H. Winchell, State Geologist of Minnesota.

It is possible, however, that successive layers of coarse and of fine sediment may be produced at a very great angle with the actual bedding plane, and with the surface of the water. This false bedding is formed under peculiar circumstances: and the first condition is identical with that necessary for the true bedding which it simulates, namely, deposition in a current. But in the true bedding, in order to produce alternating deposits, differing in size of material, a current of varying speed is required; while the false bedding is well-formed only in a current of nearly constant velocity.

In St. Louis county, northeastern Minnesota, about two miles south of Iron Junction on the Duluth, Missabe & Northern railroad, a cut in a level plain of sand and gravel shows a section a hundred yards long and fifteen or twenty feet high. The stratification appears to be well marked. At a distance, the layers are seen to dip steeply north; and even within a few yards this seems to be the true bedding, marked throughout the greater part of the section. Indeed, were it not for the peculiarity of such stratification in drift deposits, it might be passed by without suspicion. Close inspection reveals in places the real lines of stratification, often faint and sometimes difficult to distinguish. These are, in their general course, nearly horizontal, and their outline is that characteristic of ripple-marks.

Ripple-marks are often seen in the sandy bottom of shallow streams. As has often been pointed out, they present a moderately sloping surface, as that of greatest resistance, to the current; while the leeward side is steep. It was in a shallow glacial stream, therefore, that this deposit was laid down.

When it was formed the precipitation of sediment was going on rapidly. Thus the material, once formed into ripple-marks, was not disturbed and rearranged for the slow forward movement of the ridge with the current, as in regions of slow deposition; but was quickly covered up with new layers. Yet the deposition was not so rapid but that the surface always preserved the ripple-marked structure.

As each fresh layer was deposited upon the bottom, the most of it came to rest on the steeper, or sheltered, side of the ripple-marks. Thus, in the figure, if the original surface be represented by *a*, the new layer will assume the position *b*, the

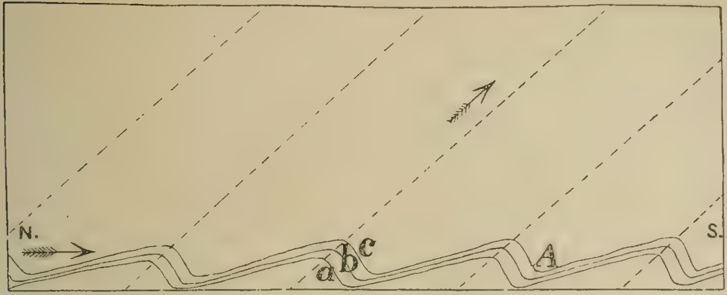

FIG. 1.—*a*, *b*, *c*, Successive ripple-marked layers of sediment. Scale, one inch to a foot

third *c*, and so on. Thus, every point of the ripple-mark moves onward and upward, at an angle with the bottom depending upon the velocity of the current and the rate of deposition,—in this case about forty degrees. The dotted lines represent the direction of this upward advance.

As the materials varied in point of size and weight, the larger fragments generally came to rest in the trough on the leeward side of the ripple-mark, that being the position where, owing to the shelter of the ridge, the current exerted least force. This happened with every fresh ripple-marked surface, and this trough (represented by *A* in the diagram), moving onward and upward, formed the layers of coarse material, which alternate with the finer sand of the gently sloping side of the ridge. Often these layers extend ten or twelve feet with perfect regularity. The real bedding, when not obscured, might easily be mistaken for a minor cross-bedding.

What material was deposited on the gently sloping side of the ridges was more exposed to the pressure of the current than that accumulated to the leeward; and the deposition being slower there, it was exposed much longer. Thus it became firmly packed. When laid open to the weather, as in this cut, these layers stand out ridgewise, while the looser and more rapidly formed parts are worn away. This hightens the deceptive appearance of stratification.

The process of accumulation is explained in figure 2, a diagram made from a sketch. The ripple-mark may be divided into three separate portions, where by accumulation are formed three distinct layers in the false bedding: *A*, the hollow immediately in the lee of the steep side, in which accumulate many large pebbles, finer gravel and loose sand; *B*, the forward part of the gently sloping side of the ridge, which mainly receives the pressure of the current and accumulates a layer of firmly packed sand; and *C*, the upper part of the steep side, where coarse fragments, on account of their weight, do not lodge, and where the force of the current is little felt. This last forms the layers of loose sand. There is often a fourth division, lying between *A* and *B*. This position receives but sparingly the coarser fragments; and it is somewhat protected from the force of the current. The result is *D*, a layer of loose sand and fine gravel, nearly like *C*.

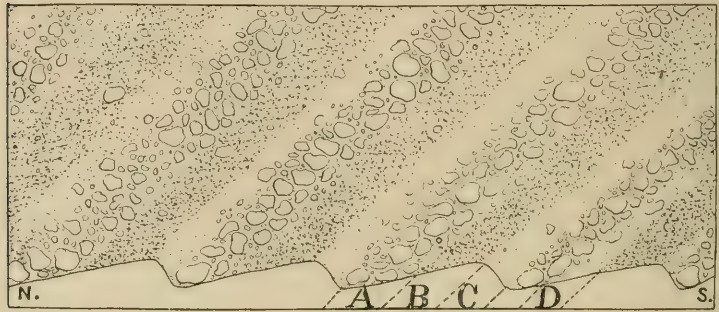

FIG. 2.—*A*. Coarse gravel. *B*. Compact sand. *C*. Loose sand. *D*. Loose sand with some gravel. Scale, one inch to a foot.

The analysis of this structure gives some clue to the conditions under which the deposit was laid down. It was in shallow water, and the current was approximately constant, both in its velocity, as is shown by the considerable extent of these false layers of coarse material (for if the velocity should change the material would also change, and so destroy the semblance of a layer), and in its direction (from the north), as is shown by the regular and unvarying form of the ripple-marks. The velocity may be estimated from the size of the pebbles in the coarse layers. The stream was able to move these along on the gently inclined slopes, but was unable to do so when they were in a place where the force of the current was slightly warded off. Thus the size of the larger fragments marks the limit of the carrying power of the water.

The average size of these larger fragments may be estimated as between two and two and a half inches in diameter. Acording to the tabulation of Mr. David Stevenson,[*] a current of three feet per second, or 2.145 miles per hour, suffices to sweep along pebbles the size of an egg. Thus we know that the bottom current was upwards of two miles per hour.

It would be far-fetched to attempt to apply the principle here dwelt upon to the solidified rocks. Yet in the case described the appearance is so deceptive that it emphasizes the danger of the hasty application of rules, without a study of each individual case.

VERTEBRATE PALÆONTOLOGY AT THE COLUMBIAN EXPOSITION; A BRIEF NOTICE.

By John Eyerman, F. Z. S., F. G. S. A., Easton, Pa.

Vertebrate palæontology in the Mines and Mining building was represented by a few and (with the exception of the New South Wales exhibit) small and isolated collections. The best exhibit by far, and, in fact, the only one worthy of notice, is in the New South Wales section; in fact, it would not be an exaggeration to say that, apart from the fossils, this section, representing principally, as it does, the mineral industry of that colony, is unquestionably the best and most interesting in the building.

In this country's exhibit there is a remarkably good collection of fossil fish from the Hawkesbury beds of the Mesozoic, which beds are characterized by the absence of the vertebral centra in the fossils, and, according to Woodward,[†] are homotaxial with the Keuper or perhaps the Rhætic. Woodward's new Dipnoi genus *Gosfordia*[‡] *truncata* is here shown by several good specimens. Of the ganoids there are a number of specimens of *Pristisomus gracilis*, several of *P. latus* and one of *P. crassus*, several of *Dictyopyge symmetrica*, *Clithrolepis granulatus*, *Peltopleurus dubius*, *Belonorhynchus gracilis*, *Myriolepis* sp., and a new genus *Apatolepis australis* Wood.

In the Japanese section, a good specimen of a teleostean is represented by a new species of *Leuciscus*. This individual

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[*] Quoted in Encycl. Brit., Art. Geology.

[†] Mem. Geol. Sur. N. S. W., No. 4, Pal., pp. 55, pl., Sydney, 1890.

[‡] Named from the locality, Gosford.

(minus the head in this specimen) measures about 130 mms., and comes from Yawataura Iki. Brazil also had a small collection from Ceara.

In the Mammalia, New South Wales exhibited a collection of marsupials. In the annex to this country's exhibit, on the west side and directly across the aisle from the main exhibit, there were some fine casts of the mandible, femur, pelvic girdle, etc., of *Diprotodon australis*, the only species of this extinct family at present known and the largest of the entire Marsupialia. Locality: Pleistocene, near Myall creek, Bingera. The pelvic girdle shows the so-called marsupial bones extending upward from the symphysis. In the catalogue there are no less than 113 specimens of various parts of *Macropus* (Kangaroo), Nototherium (which is similar in many respects to *Diprotodon*), *Thylacinus* (Tasmanian wolf), *Thylacoleo* (Phalangers), *Phascolomys* (wombat) and *Sarcophilus*.

In the Brazilian exhibit there were bones of the *Mastodon* and *Megatherium americanum* from Bahia, and of *Mastodon* from Ceara, and the Japanese section exhibits teeth of *Elephas primigenius*.

Besides these, there are restorations and casts in the United States Government building and more particularly in the Anthropological, as well as photographs and a few casts in the Mining and in the galleries of the Liberal Arts buildings. It is to be regretted that the casts of some of the most remarkable species in our extinct mammalian and reptilian faunas were not exhibited.

EDITORIAL COMMENT.

The Columbian Exposition.

A hasty glance taken in August, 1893, at the ores of the noble and useful metals in the Mines and Mining building.

(Continued.)

Foreign Countries.

Bolivia.

Bolivia is not mentioned in the official catalogue consulted by the writer, but contains in the 20 feet square allotted to her as much of interest as many countries which enjoy that distinction.

Among other exhibits are cases of lead (probably argentiferous), but without labels specifying the localities. Bottles containing mineral salts, borax, etc., barks and woods, with an ornamental table of inlaid woods, representing various musical instruments, India rubber plants and articles made of crude rubber were grouped together without system. Piles of rocks with frequent opal are backed by paintings of the park at Cochabamba and a full length portrait of Bolivar (?).

CHILE.

The exhibit from this country is almost exclusively of nitrates and illustrates that industry well, but of her important and rich mines of the precious metals there is not a trace. It is unfortunate that this is the case, and more so if the cause be the recently strained relations between Chile and the United States.

ECUADOR.

About 20 feet square is occupied by this republic, and has for background maps of Guayaquil and Quito. On the northwest corner are books descriptive of gold mining in Ecuador, placer mining of the Playa de Oro Mining Co., and of the Codigo de Mineria de la Republica de Ecuador, Quito, 1886. A chain of gold nuggets. The Esmeralda and Angostura placer mines. Silver mines Pilzum, Cañar ores and minerals with a map. In the southwest corner are ores from the Playa de Oro silver mines. Pilzhun ornamental, decorative stone and coal, and various salts. Masses of sulphur. In the center is a heterogeneous mass of rocks, ores, and building stones. This exhibit is also omitted from the above mentioned official catalogue.

BRAZIL.

Brazil, whose exhibit exists in spite of the oversight of Mr. F. J. V. Skiff and Moses Handy, attracts the attention of the visitor by a triple column of gilded cubes representing gold, and showing the little profit in the mining of 46.55 tons of gold from the Minas Geraes. The expenditures were 31.49 tons, and the profit 15.06 tons. Another pyramid of gilt boards represents the value of the product of Minas Geraes from 1720 to 1820 as $303,080,000.

Lignites and coals from Rio Grande do Sul; building-stones, crystallized minerals and copper ores from Minas Geraes; bombs of siliceous iron ore, pyrrhotite and various samples of iron ore, also from Minas Geraes; also a fine geode of quartz crystals.

The material is insufficient and compares badly with the mineral exhibit of this state at the Philadelphia Centennial in 1876. It is without scientific arrangement. Dr. Motts is the commissioner of minerals in charge.

FRANCE AND FRENCH COLONIES.

Rhodochrosite and carbonates of manganese from Las Carknes, near St. Girar (Ariege); large and handsome specimens of calamine and galena (Camarsal).

New Caledonia nickel ores and products (cobalt and nickel make another exhibit in the Tonkin pavilion) exhibited by the society "Le Nickel"; asphalt works at Seyssel; bituminous limestone; photographs of the process of paving the streets of Paris with it.

In the French Colony exhibit in the pavilion dedicated to Annam, are cobalt ore from New Caledonia, a jar of small cubes of nickel, one jar of pure nickel oxides and nickel castings exibited by the society "Le Nickel," 13 Rue Lafayette, Paris: also bituminous coal from New Caledonia.

GERMANY.

The most prominent object in the German department is the splendid exhibit of steel rails in the form of a pyramid by Stumm Bros., of Neunkirchen, and Randolph Bocking, of Halbergerhütte, with an artistic bronze figure in the center, with bronze figures of miner and furnaceman at the base. A case of the tests of the product is at the side, and contains beautiful sections. An admirable display of washed and crude ores with sweat apparatus and cold bending test; oligistes hematites and specimens of iron fractures.

Permanent stone buddle of the Humboldt Co., near Cologne; cases of gems and of amber, and chemical manufactures. For background a picture containing the Bay of Naples, offices in

Frankfort on Main, and smelting works in Spain. The ores and methods employed at Clausthal and Freiberg, and especially the latter, are conspicuous by their absence.

Among the most notable objects exhibited by the German government are hand specimens of ores from the upper Harz veins, and of the lower Harz (Rammelsberg) deposits; reagents, middle and end products of the lead works of the upper and lower Harz; ore, middle and end products of the smelting works at Oker; specimens from the royal Friederichs mine; middle and finished products of the royal Friederichs smelting works; pyramid of gangue, iron ores and spiegel iron; specimens of pig and spiegel iron; new analytical method for the quicker separation of iron, manganese, cobalt, copper, aluminum, chromium, etc.

GREAT BRITAIN AND HER COLONIES.

Antimony ore from Dumfriesshire, Scotland; arsenical pyrites from New Cook's Kitchen and Levant mines, Cornwall and Devon Great Consols mine; cobalt from Foel Heraddug mine, North Wales; copper ore from Corriston, Lancashire; gold ore and auriferous quartz from the Morgan gold mine, North Wales; iron ore from Gillfoot Park Mining Co., Egremont, Midland Co.'s mines at Frodingham, Lincolnshire, Park iron ore mines, Hodbarrow Mining Co., Winford, Northamptonshire and Antrim Iron Ore Co.

Lead ore from Snailbeach mine, Shropshire, Mawston mine, Derbyshire; Milnor, Holywell, Flintshire, South String, Lancashire, Rushen mine, Isle of Man, East Darran mine, Cardiganshire, Old gang, Swaledale, Halkyn, Meitz Wood, Cornwall, Great Laxey, Minera, Wrexam, Foxdale, Van mine, Llanidloes.

Manganese ore from Benallt, Rhiw, Llyndywurchen, Harlech (N. Wales), Merionethshire, Craig Uchaf, Llanbedr.

Zinc ores from Mawston, Derbyshire, Truastell Conway; Milwr Lid, Flintshire, Old Milwr shaft, Halkyn mines, Wrexam and Talare mines, Holywell. Blende from Moelwyn, Mona and Parys, Anglesea, Great Laxey, Mining Co., Lid, Isle of Man, Minera mine Wrexam, and Van mine, Llanidloes.

Johnson, Matthey & Co. make a unique exhibit of the pure rare metals; ingots of platinum, and iridium-platinum;

melted rhodium, electrolysing apparatus, metallic osmium; ingots of palladium; tubes and spout of platinum for sulphuric acid manufacture; gold-lined platinum dishes: metallic ruthenium; an ingot of 266 ℔s. of platinum melted by oxyhydrogen blowpipe.

Indian Empire.

Gold quartz and iron ore from Mysore, South India.

Cape Colony exhibit.

Piles of "diamondiferous ground" and of bituminous coals. A central case of minerals, and a table of crude crocidolite. A large pile of copper ores. Chalcopyrite from the Otkiep mines, Namagua land. Electric car photographed in Kimberley. Fine specimens of asbestos. A bag of asbestos. Fibrous manufactured crocidolite.

The process of extracting the diamonds from the diamond-bearing earth and of cutting and polishing them are illustrated.

New South Wales.

Brown hematite, coke from washed coal; brown hematite, Fitz Roy mines, Mittagong; lode tin ores, Poolamacca, Barrier range; brown hematite, Blayney; minerals of manganese, copper, asbestos and chrome iron ore.

Alley Point, near Nundle, auriferous stibnite, Cudgegong, Pretty Gully, Lady Carrington mine, New Armidale; fine pile of manganese ores from Woodstock, near Coura; limonite near Blayney, Cliefden Homestead; magnetite, Bowling Alley Point, near Nundle. The exportations from New South Wales here follow:

FROM 1851 TO 1891.

Gold	$187,758,698
Silver and lead	54,978,350
Coal	124,195,672
Petroleum and kerosene shale	6,885,269
Iron	1,864,115
Tin	46,300,228
Copper	29,273,874
Antimony	562,778

CANADA.

Galenite from Sault Ste. Marie, Ontario; stibnite (Rawden); sphalerite, Calumet Id., Que.; chalcopyrite, Bolton, Que.; bornite (Cleveland, Que.); magnetite, Queen Charlotte Ids., B. C.; Grandison, Que.; hematite, McNab, Ont.; models of the gold nuggets found in the province of Quebec.

Besides these are splendid specimens of mica, graphite, gems, tourmaline, etc., and a fine series of hand specimens of rocks and geological maps.

Nova Scotia.

Gilt pyramid exhibiting the gold production to 1893, which has been 551,000 ounces; copper ores from Cape Breton county; manganese ore from Hunts county; brown hematite from Coldister county; case of gold nuggets and gold quartz by the Government of Nova Scotia; Truro Mining Co., Carriboo district.

Ontario Section.

The exhibit of nickel ore by the Canadian Copper Co. is very extensive and includes masses of copper and nickel ore weighing respectively three, four and six tons. Samples of the selected copper and nickel ore are displayed on one side. Numerous photographs line the walls of the center pillar; specimens of the graded ore, as well as of the finished products, alloys and pure metal are seen in the show cases. The whole subject of the treatment of the copper-nickel pyrrhotite in the diorite gangue, from its mechanical sorting to its treatment in the roast pile and its extraction as matte in Bessemer converters and its transformation into an alloy of about equal parts of copper and nickel, or the elimination of the copper and the resulting nickel of nearly 99% purity, is one of the most interesting in the department of Mines and Mining.

The entire exhibit, as to arrangement, labeling and material, is one of which its managers have every reason to feel proud.

British Columbia section.

A very complete series of argentiferous galena from the Slocan district; magnetic iron ore from the Kamloops district; zinc ore from the Burrara district; gold quartz from the Carriboo district, silver lead, E. Kootenay; mercury ore, Barclay Sound, V. R.; mercury ore from Kamloops; case filled with lead and iron ores; gilt plaster pyramid representing in gold ingots the output of the gold from placer mines of British Columbia since 1858, *i. e.* $53,512,652.

MEXICO.

This exhibit occupies a large space in the southwest corner of the Mining building. The collections are arranged well in 28 cases of modern and excellent construction, and on separate pedestals. The cases are boxes of iron with glass sides, about seven feet wide and fourteen feet long, on feet which support them about one foot from the floor. The shelves are of glass about ten feet long and twenty inches wide, and two and one-half feet between them. The ores, solutions, and products of the Hacienda del Progreso are very well displayed, except that the labels are not easily read and there is not enough information as to localities. Silver and copper from Michoacan de Ocampo. The second case on the south side is chiefly filled with clays and building stones. The third case is filled with minerals which unfortunately rest on their labels so that the latter cannot be read. In cases where the labels can be read they are in technical Spanish, not intelligible to the ordinary visitor. The fourth case shows argentiferous, plumbiferous and ferriferous ores from the El Carmen mine. The fifth case contains minerals of the heavy and light metals indiscriminately. The sixth case contains argentiferous ore from various mines and much associated zinc ore. Case No. 7 contains minerals of the heavy and light metals. Case No. 8 has a mixed assortment of minerals and building stones. Case No. 9 contains building stones and clays. Case No. 10 has coal from Michoacan de Ocampo. Case No. 11 contains mixed minerals and various grades of ores, but without explanation or description. There is an elevated map of a district of Tetzicoco, Xochimilco and Chalco. Case No. 12 has minerals from Pachuca and other localities. This collection is valueless because the labels are displaced or covered. Case No. 13 has fine "exemplares minerales" of galena, malachite, etc., from unknown localities. Case No. 14 has galena and other ores from Durango and Chiapas. The copper minerals from the latter are especially fine; and handsome specimens of Mexican onyx. At the southwest end illustrated topographical and other maps of the Candelaria mine, the metals produced from its ores and fifteen photographs. Case No. 16 has a collection of fossils, minerals and photographs. Case No. 17 has a column of building stones. Case No. 18 contains a fine collection of silver ores from the Roncevellas, San Domingo, Penasquito, Todos Santos and Cinco de Mayo veins by the Batopilas Mining Co.,—large masses of ore from the Porfirio Diaz shaft of the Esperanza workings 280 feet below the tunnel. Assay value $20,000 per ton. Case No. 19 has building stones, onyx slab and stalactites. Case No. 20 has a collection of rock specimens from localities not named,—opals and the matrix in which they occur. Case No. 21 has a column of very handsome building and decorative "rose garnet" stone, and a thin slab showing the light of an incandescent lamp through it, from Xalostoc, Mexico. No. 22. Slabs of Mexican onyx. No. 23. Slabs and veins of prettily veined onyx. No. 24. Case of ores, building stones and salt of Valisco. No. 25. Silica quartz and building stones. No. 26. Minerals, ores and rocks from Zacatecas. No. 27. Minerals, ores and country rock from Zacatecas. No. 28. Minerals and ores from the Maravillas Co, in Pachuca, State of Hidalgo. Le Ley, Sta. Anna, Sta. Gertrude, El Pebillon, El Carmen, Amistad of Concordia, and the Real del Monte Co. (Labels principally covered.) No. 29. Ores and minerals of Chihuahua and Durango. No. 30. Murdock & Compania, Mina del Cedral, Estacia de Baroteran, Coahuila, light yellow earth. No. 31. Sulphur ores and salt, Real del Monte, Pachuca; white clay ore, Puebla; white earth. No. 32. Puebla building stone, Michoacan. No. 33. Zacatecas ores and minerals. No. 34. Ores and minerals from Oaxaca, chiefly silver, lead and copper. No. 35. Real del Monte ores and country rock, blue vitriol and manganese ores; upper case, Chihuahua rocks and minerals. No. 36. Rocks and chalcopyrite, and various minerals—no classified labels. No. 37. Rocks, minerals and ores, imperfectly labeled.

ITALY.

Sulphur, building stones, marble, and statues of the last; exhibit of Vanzetti, Sagramoso & Co., of iron and steel foundry; forged and foundried pieces, Milano, but no ores; piles of copper, tin and antimony, ingots and ores. This display is, in its own line, the finest in the building. A large column of the products of the Kerosene Oil and Mineral Company.

JAPAN.

A case of splendid specimens of stibnite from Hyago; a case of mineral and rock specimens of small size; stibnite, Loc Osboin Igo. An interesting historical exhibit of ancient mining and smelting in Japan; models and drawings of the Anio copper mines; graphite crucibles; large mass of chalcopyrite from Skiti province; ingots of copper; copper and brass wire.

Gold and silver from the mines of Sado island, the Aikawa and Tsurushi mines; stephanite and myargyrite from near the Innai village; argentite from the mountains near Handa; argentites with barite and galena from Karnizawa; a mixture of galena, zinc blende, pyrite, chalcopyrite, and gray copper, called locally, "kuromono," or black ore, lies in tuff at Kosaka. *The Towada Mine.*

Argentites and copper pyrites in a clay and gypsum gangue on the west shore of lake Towada; the Omaki silver mine of the red oxide from the province of Ugo; the Tsubaki mine, consisting of silver chlorides, in the same province; the Kamioka mine in the town of Funatsu, produces argentiferous galena and chalcopyrite with zinc blende, malachite and chrysocolla.

The Mozumi silver and copper mine, in Hida province, produces argentite and galena with zinc blende, chalcopyrite, and pyrite. The Hadasa mine, in the province of Mino, gives argentiferous copper and galena.

Of the copper mines, which produce the metal forming the chief metallurgical industry in Japan, are the Ani mine, which really comprises seven mines, in the province of Ugo; the Ashio; the Besshi; the Arakawa; the Omodani; the Kusakura; the Ogoya; the Yoshioka; the Osarusawa; the Komaki; the Kokusei; the Ose. Antimony is obtained from the Ichinokawa; iron sand mines are the Neu, in the Hoki province and the Yoshida, in the province of Idsumo. Sulphur, coal and petroleum are produced in large quantities.

The volume issued by the Director of the Mining Bureau of Japan, Mr. Wada Tsunashiro, is a very clear and complete statement of Japan's mineral wealth and the history of its development, and is a necessary aid to the understanding of her display.

RUSSIA.

The floor space occupied by this exhibit is about 60′x70′. It was tastefully arranged and decorated with flags. One of the most striking objects on entering the enclosure was the inevitable objective presentation of the gold yield of Siberia and European Russia by means of three gilt pyramids made of proper sizes to represent the gold mined from 1745 to 1891.

The product of East Siberia between these two years was	**1,097,232**	**kilogr.**
Western Siberia	**109,990**	**"**
European Russia	**458,844**	**"**

Silver and lead ores were shown from the Sadon mine and the Alaghire smelting works. Zinc ores, metallic zinc and other products from the Dombrowa, and a few specimens of cinnabar and manganese ore from South Russia, also nickel and cobalt; iron ores from the Nontruska and Mada villages; small specimens of magnetite from the Blagodat mine in the Blagodat mountain, the latter illustrated by drawings and models. A model is shown also of the Choroblagodotsky iron works. Cases of iron wares, thin sheet iron and other interesting products and tools are exhibited in connection with these. Handsome specimens of azurite from East Siberia are shown.

The individual exhibits are good, but the arrangement, though pleasing to the eye, lacks some system, which would facilitate its study, and the labels were strikingly inadequate. The rock salt, petroleum product, sulphur, etc., besides the finely executed geological map, the latter probably under the direction of the able Chief Geologist Serge Nikitin, deserve attentive study and merit commendation.

SPANISH COLONY OF CUBA.

About 48x60 feet was accorded to the exhibit of this country. A collection of galena and other ores in cases and jars without labels were among the first objects observed; specimens from Santiago de Cuba, containing a large representation of the Spanish American Company's ores from Yucca, Perseverance, Union, etc. Several cases of minerals were followed by stands supporting large blocks of galena from the Arroyanas mine, province of Jaen; a model of an open retort furnace for mercurial ores, in wood, four feet long; iron and copper ores from Ponce P. R.; coals and slates and asphalt from Angela Elmira, Cuba.

Gold

Is found in the mines of Holguin, 25 miles from the coast, in the Eastern Department. The auriferous zone is situated about five kilometers from the city of Holguin and runs, approximately, northeast and southwest. The veins of the precious metal dip more or less than 45 degrees, between serpentine rocks. They were opened by a Cuban in 1836, abandoned in 1860. but work on them was resumed later by Don Vicente Guillen. Mr. Coltman, by a very imperfect method, found four ounces of gold to the ton, equivalent to $70. This brilliant result was fully confirmed by experiments in Philadelphia and London. Prof. James C. Booth (of Philadelphia) reported that the metal obtained by the reduction consisted, at least in two experiments, of three parts of gold united to a white metal, probably iridium-osmium. Some specimens of the ore analyzed in Cuba gave 3 to 5 ounces of gold per ton. The principal mines are "La Oriental," "Aquipada," "La Central," "Nuevo Potosi," "San Juan Bantista," "San Isidoro," "Holguinera," all contained within two leagues of terrane.

The following description of the "San Atanasio" mine is given literally in the words of the prospectus which was furnished the student of this part of Cuba's mineral wealth:

ISLAND OF CUBA.

THE GOLDEN MINES NAMED

"SAN ATANASIO."

This *Mine* belonging to Mr. *Martinez & Co.*, is situated in the farm *Descanso* in lands of *Guaracabulla's* village; from which place it is only fifteen minutis away; in the province or state of *Santa Clara*, and seven miles to *Placeta's* village, being this place the end of the *Caibarien* Railway-line.

The *San Atanasio* Gold Mine embraces a piece of land of about more than twelf acres; or by Cubans measure 58,080 square yards. In grounds of this Mines is a large building which comprehend; Machinery building with a compleat *Wiswell Grinder*, moved by a fourty horse power Boiler and Engine; an elevator engine; four horse power, an top of a well and to which engine is adapted a "Dunkey" to lift up the water. Besides this building it has a beautiful dwelling-house, lodgings for laborers and so fort; all this buildings, were made and brought from the United States of America having employed in their construction the hardest and best wood, from the above named place.

The works, or diggens made or realized in this Mine are compossed, of tow wells, one of 125 feet deep and the other of 75 feet, connected by themself with a principal gallery only 25 feet deep onder the level of the ground.

There are, distinctly to the sight, as well in the gallery as in the wells, different *vein of ore* and lines producing gold; and of one this lines, which runs all throug the gallery and is 12 inches wide all along is the piece of gold wihich is at sight.

From this same *vein of ore*, or line it has been drawed out four *Tons of Mineral* which after been melted and grinded (empirically way) and without any scientifical direction;—and only to trie the Engine and Grinder have produced four small *bars of pure gold* one weighing sixteen ounces which was sold for the price of $300 and the other is the piece joined to the *Mineral* and at sight to the public which optained the first primiun at the *Regional Exposition of Santa Clara.*

Havana, March, 1893. Ezequiel J. de la Auja.

Iron.

José Ruiz, of Leon, was the first to "denounce" an iron mine in Cuba (so says the Spanish guide book), which he did three or four minutes past noon on the 26th of January, 1881. Without the initiative of the gentleman (it adds) these rocks would have been forever undiscovered!!!

The first group, distant from Santiago de Cuba about six kilometers, is three kilometers in extent and is called Dorotea. It is composed of five mines entitled San Lino, San Ignacio, Dorotea, S'tra S'ra, del Recreo y Criolla, with a total area of 300 hektares. The analysis of these ores is as follows:

Moisture	0.95
Metallic iron	63.20
Metallic manganese	0.90
Silica	0.42

The second group is that of the Sevilla and Ocaña, eight kilometers east of Santiago de Cuba, and six kilometers in extent. The mines are the Rosa, Concha, Palafingell, Justicia, Calaboon, Doloritas, Lopez, Antoñica, Reus, San Andres, Joturo, Joturito.

Various analyses of this group give the following result:

	1	2	3
Fe	65.44	63.50	66.04
Mn	1.27	0.36	2.53
$Al_2 O_3$	4.43	0.80	0.25
Soluble silicates	10.36	6.18	4.10
Ignition	4.05	3.18	4.78
Sulphur	0.06	0.27	0.27
Phosphorus	0.03	0.33	0.20

The Carpintero group, distant twenty kilometers east of Santiago de Cuba, and six kilometers from the sea, contains the mines Yuca, Grande, Pequeña, Carpintero, Yuquita, Reforma, Polux, Castor.

Analyses of these ores give:

	1	2
Fe	61.00	68.50
SiO_2	5.00	10.50
P	0.009	0.036
S	0.045	0.148
Moisture	0.000	0.000 (?)

This group is found 750 feet above the level of the sea.

The cost of mining is as follows:

	Per ton.
Mining and placing on cars	$ .95
Transportation to ship	.65
Transportation by sea	1.65
Duties in the U. S	.75
Other charges	.15
Total cost	$4.15
Profit per ton	$1.70

The Juragua group consists of the Abundancia, Union, Suburense, Perseverancia, Jupiter, Firmeza, Vulcano, Resolucion, Fomento, America, Constancia, Empresa, Concordia. The mining of these ores is by open cut.

Analysis.

	p. c.
SiO_2	1.90
CO_2	0.98
Fe_2O_3	95.15
Al_2O_3	0.55
CaO	0.67
MgO	0.15
Mn_2O_3	0.50
S	0.07
TiO_2	0.03
Organic matter	0.00 (?)

This company has exported from 1884 to 1892, 1,806,505 tons.

The group Magdalena, or Lolas, consists of Lola, Lola 2, Barcelona, Resurrexit, San Antonio.

The Providencia group consists of San Rafael, La Llave, La Cerradura, Sta Rosa, Alfredo, Alberto, Norte.

The group Retiro and Economia comprises the San José, San Rafael, Cren de Ritas, Triangulo, Conveniencia, Girasol, Plano, Alianza, Constancia, Escondida, Elvira, Elvirita, Magdalena, Mariana y Rafaela, Graña Kubie, Carmen, Carlota, Sur.

The group Güira y Cajobabo.—Concepcion, Stma Trinidad, Duarte, Paulina, West, Este, Pilar, Pater, Cuba, San Sebastian, Laura.

The group Berraco containing Ave Maria, La Trinidad, La California y Nueva Caridad.

Group Ubero.—Fausto, Fausto 2, Bufera, Falconera, Clarence, King, Skilton, Delicia, Mascota, Antonia y Carolina, Isabel, Ceres, Vesta.

Group Sigua, or Awayo de la Plata.—Rea, Alfeo, Awayo de la Plata and Avetusa.

Group Limoncito.—San José and Manuelico. Mineral zone west of Santiago de Cuba.

Group Nimanima.—Algeria, Boston, Philadelphia, Nueva Bilbao, Laffayette, Denver, Yunque.

Group Cuero.—Enrique, Aragon, Picardia, Acorosait, Caldwell, Mina A, B, and C, Solo.

Group Guama.—

Analysis of various mines:

	p. c.
Fe	59.12
SiO_2	14.85
P	0.38
S	0.49

Copper.

Four leagues northeast of Santiago de Cuba is the Villa del Cobre, near which are grouped many copper mines. The old mines of Consolidada, Isabelita, Santuario, San José, San Joaquin, Perseverancia, Angelita, San Andres. Two kilometers north of Santiago de Cuba are other copper mines, towit: San Pedro, San José N Sra del Carmen, San Francisco, San Feliciano, Ntra Sra de Dolores.

The Cuabite group is composed of Conchita, Encarnación, Mina Española Noertina, Cuba.

There are copper mines near Sigua, with ±40 to 48 per cent. of copper, and the group of Brazo de Canto, which latter is composed of four mines, the Triana, San Jose, San Fructuoso, and Mayor.

There are eighteen groups of manganese mines and three groups of mines of chromic iron; also three groups of lead mines, one of the latter containing zinc, silver and gold, and the other two lead and silver.

All in all, the mining industries of Cuba, both in metals, which have been briefly noticed, and in asbestos, asphalt and guano, are well represented and industriously and systematically catalogued, in the official guide in the Spanish language. It is to be regretted that the mother country is so ill represented in the building.

CONCLUSION.

In summing up the notes made on this display of the ores of gold and silver and of copper, iron, tin, antimony, lead, etc., etc., it is incontestible that an assemblage of ores gratifying to the eye has been made. Many of the individual exhibits are complete and their framing is made in good taste and with conscientious fidelity, and yet as a whole it is disappointing, not so much on account of inadequacies and total deficiencies (though these are very frequently apparent) as because it is rare to observe any effort to use the collections for the instruction of the public. The aim has been to dazzle and please the eye, but those who went through the separate pavilions prepared to study and profit by their contents have not been sufficiently recompensed for their time.

No uniform system was adopted for the pavilions as a whole nor for each by itself. It was too apparent that the arrangement was governed by the sizes rather than by the characters of the objects, and by the desire to impress the visitor with the magnitude rather than to teach him. Much negligence was shown in the detail of labels, and the fact was not sufficiently considered that what might be a sufficient description of an object in a case containing a small collection, was very insufficient for a world's fair. The labels themselves were too often missing, incompletely made out or useless on account of being covered by the specimens. Many of the most important localities have not been represented at all.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Some Maryland granites and their origin. By CHARLES ROLLIN KEYES. Bulletin of the Geological Society of America, vol. iv, pp. 299 304, with a plate; July 31, 1893. The eastern part of the Piedmont belt in Maryland is described as consisting chiefly of gneisses broken through in many places by eruptive rocks, as gabbro, diorite and pyroxenite, until these basic eruptives occupy fully half of the present exposed surface. The granites are found in small areas, to the number of a dozen or more, intersecting both the foregoing igneous rocks and the gneiss. Although these granites have been held by some investigators to be metamorphic from mechanical sediments, the author confidently maintains their irruptive origin from an acidic molten magma cooling under pressure. Sometimes, as at Dorsey's Run, the granite is seen to have been forced between beds of twisted and puckered gneiss, and at Woodstock huge blocks of gneiss are enclosed in the granite. At Sykesville a great variety of fragments of foreign rocks, from minute pieces up to blocks of large size, occur as inclusions in the granite, comprising limestone, soapstone, pyroxenite, vein quartz, and hornblendic and biotitic gneisses. All these rocks are well represented in outcrops several miles eastward, where they dip to the west. In most of the fragments the outside to a depth of two to four centimeters or more is much changed, but the interior of the larger pieces often or commonly exhibits the rock in its original character. Aside from the usual microscopic indications that the granites have cooled from fusion, another evidence of this is afforded by large grains, micropegmatitic intergrowths of quartz and feldspar, which appear to have been rounded and occasionally hollowed on their sides by magmatic corrosion.

Epidote as a Primary Component of eruptive rocks. By CHARLES ROLLIN KEYES. Bulletin, G. S. A., vol. iv, pp. 305 312, with four figures in the text; July 31, 1893. The epidote of certain Maryland granites is found in isomorphous growths with allanite, as well as in separate well-defined crystals. That it must be there an original constituent, and not a secondary product, appears from its presence in perfectly fresh rocks, or those which have been but slightly altered by orogenic movement; by its inclusion in sphene, one of the first minerals to crystallize from the molten magma; and by its sharply defined crystallographic faces, completely mantled by unaltered biotite or feldspar, and giving shape to these essential components of the granite.

Relations of the Laurentian and Huronian rocks north of Lake Huron. By ALFRED E. BARLOW. Bulletin, G. S. A., vol. iv, pp. 313-332; August 4, 1893. This paper is a revision and extension of one published by Mr. Barlow in the AM. GEOLOGIST of July, 1890. The Laurentian gneiss and granite are shown to have been irruptive and in a molten condition subsequent to the deposition and lithification of the Huronian sediments. The Huronian system, therefore, is regarded as the oldest of sedimentary origin known in that region; and it is supposed to have been laid down on a firm floor of rock analogous to granite. Fusion, irruptive flow, and recrystallization of this granitic floor are thought to have produced the Laurentian gneiss, whose parallel foliation of the component minerals and alternation of coarse and fine bands are believed to be magmatic flow structure. Fragments of the Huronian rocks are inclosed in the gneiss, and the latter sends out coarsely crystalline seams, which are interstratified with the Huronian beds, and dike-like apophyses which cut these beds transversely.

The Archean rocks west of lake Superior. By WILLIAM HENRY CHATTERTON SMITH. Bulletin, G. S. A., vol. iv, pp. 333-348, August 4, 1893. We read this able essay with deep regret that its author was not spared for further work. His death occurred soon after the society's last winter meeting, for whose success he had been very active as secretary of the local committee. The essay treats of the part of the Dominion of Canada from the Lake of the Woods eastward to the Thunder Bay district north of Lake Superior, and from the international boundary north to the Canadian Pacific railway. The lower Archean or Laurentian rocks are granitoid and gneissic, occupying more than half of the country as large rounded or ovoid areas, like those mapped by Hitchcock in New Hampshire, by Barlow north of lake Huron, and by Lawson in western portions of this district. Surrounding and generally dipping away from the nuclear granitic areas, the upper Archean rocks constitute an irregular network and comprise in ascending order the Coutchiching and Keewatin series of Lawson, the former consisting of gneisses and mica schists, and the latter of plutonic, volcanic and pyroclastic rocks. Since the accumulation of the upper Archean series, the basal granites and gneiss have been molten and their contacts with the overlying rocks are nearly everywhere distinctly irruptive. In its present condition and relationship, therefore, the so-called Laurentian system in this part of Canada is held to be of post-Keewatin age, as was first announced by Lawson. Richly gold-bearing quartz veins are found in the Keewatin rocks of the Lake of the Woods; and nickeliferous diorite has been recently discovered near the mouth of this lake.

Bulletin of the Geological Society of America. Proceedings of the Fifth Annual Meeting, held at Ottawa, Canada, December 28, 29 and 30, 1892. H. L. FAIRCHILD, Secretary; JOSEPH STANLEY-BROWN, Editor. Vol. iv, pp. i-xi, 371-458; Sept. 23, 1893.

Between the brochure last noticed and this final part of the volume are two papers: The Laurentian of the Ottawa district (pp. 349-360), by R. W. Ells; and Height of the Bay of Fundy coast in the Glacial period relative to sea-level, as evidenced by Marine Fossils in the Boulder-clay at St. John, New Brunswick (pp. 361-370), by Robert Chalmers. Somewhat full outlines of each were presented in the AM. GEOLOGIST for last February and March.

In this brochure are comprised memorial biographic sketches of Dr. T. Sterry Hunt, Prof. J. S. Newberry (with portrait), and Dr. J. H. Chapin, fellows deceased in the year 1892, with bibliographies of their writings; and the following papers, either in full or by abstract: Note on Fossil Sponges from the Quebec group (lower Cambro-Silurian) at Little Metis, Canada, by Sir J. William Dawson; A Fossil Earthquake [of New Madrid, Missouri, in 1811, continuing with shocks of diminishing intensity during the next two years], by W J McGee; Notes on the Glacial Geology of western Labrador and northern Quebec, by A. P. Low (see the AM. GEOLOGIST, March, 1893, p. 176); The supposed Postglacial Outlet of the Great Lakes through lake Nipissing and the Mattawa river, by G. Frederick Wright (l. c., April, 1893, p. 243); Notes on Geology of Middleton island, Alaska, by George M. Dawson (l. c., p. 244); The Huronian Volcanics south of lake Superior, by C. R. Van Hise; and Two Overthrusts in eastern New York, by N. H. Darton. The membership of the Society July 31, 1893, was 224.

The Cause of the great Earthquake in Central Japan in 1891. B. KOTO. (Reprinted from the Journal of the College of Science, Imperial University, Japan, vol. v, pt. IV, 1893.)

Prof. Koto, who holds the chair of geology in the Imperial university, has made a very thorough investigation and presentation of this remarkable and very destructive earthquake, in respect not only to the geological agencies involved, but also the effects produced. The work is accompanied by plates XXVIII–XXXV, four of them being "collotypes," by G. Ogawa, which are almost equal to actual photographs.

The location of this earthquake was in a fertile and populous plain, known as the provinces of Mino and Owari, on the Tokaido. It is bounded on three sides by masses of mountains composed on two sides of Paleozoic formations with subordinate areas of later granite, and on the other side of granites, gneiss and mica schist of older date. The plain is crossed by several rivers which fall into the bay of Isé, and ranks among the most populous and fruitful of all the rice-producing districts of Japan.

The first shock, which was the most severe, buried thousands of living people beneath the debris of their houses, and occurred on the morning of Oct. 28, 1891. The succeeding shocks, however, were accompanied by fires which broke out among the ruins. The city of Nagoya was in the center of the area most shaken. It is an alluvial plain, and indeed, in all cases the lowest lands suffered worst. The ground was riven with myriads of fissures and small mud-volcanoes were thrown up along the banks of the streams, while long, parallel fissures produced a falling away and opening of the banks of the rivers. For a distance of twenty miles a road ran through a nearly continuous line of village settlement. This became simply a narrow lane between two interminable heaps of debris. The cities of Gifu, the provincial capital, Ogaki, and Kasamatsu were completely overthrown and then consumed by fire. According to the official returns, about seven thousand people lost their lives, seventeen thousand were wounded, and two hundred and seventy thousand buildings were leveled with the plain, while six thousand houses, less shattered by the shocks, were burnt down by fire. Engineering works, such as canals, bridges, dams, embankments, railroads, were involved in the great destruction.

Seventeen separate quakes had already been recorded by the seismograph in October, prior to the 28th, all, however, confined to the vicinity of Tokyo. Central Japan, where the devastation was wrought, had remained quiet, and afterward, to the close of November, no less than 1,757 earthquakes were recorded at Gifu and 884 at Nagoya, and down to the end of March, 1892, 2,588 at Gifu and 1,093 at Nagoya. The great excess at Gifu indicates unmistakably that this city lay nearer to the origin of the convulsion than Nagoya.

There was no volcanic outbreak, but an enormous fissure was found to cross the country, "cutting hills and paddy fields alike," throwing the soft earth into enormous clods and ridges, which could be traced in a northwest-southeast course along the Neo valley for a distance of forty miles. "It starts from about the village of Katobira, not far from Katsuyama, on the bank of the Kiso-gawa, on the Nakasendo, running northwestwards up to Fukui, in Echizen, through the Neo valley." This fault is supposed to have pre-existed, and a renewed movement along substantially the same plane of fracture, is believed to have been the prime cause of the earthquake. There was a vertical movement, and at the same time a horizontal shifting. Large amounts of earth slipped from the mountain sides, so that practically the sides of the valley had slidden into the river. In the upper part of the dale the greater part of the mountain slopes,had "slipped away, carrying with them the forests they were covered with." The author describes, with illustrations, the phenomena observed by him throughout the course of this fault line. While these landslides characterized the course of the fault in the hilly districts, in the plains great undulatory waves of disturbance threw the surface into tumultuous confusion. The jelly-like nature of the alluvial region served to perpetuate the shocks and to multiply them, and to allow the permanent sinking of large areas which became at once filled by some of the streams that crossed the region, submerging farms and villages.

Text Book of Geology. By ARCHIBALD GEIKIE, *Director-General of the Geological Survey of Great Britain and Ireland.* Third edition, revised and enlarged, 8vo, cloth, pp. xvi and 1147, maps and many text illustrations. Macmillan and Co., London and New York, $7.50, 1893.

No text book of geology can long supply the demands of advanced geological students without revision. The progress of the science is rapid, and new text books and manuals appear with rapid succession. This edition contains 150 pages more than the last, and the improvements, which are found in all parts, bring the work substantially up to the present condition of the science. There are two characteristics which this work presents. First, its order of arrangement consists of a gradual descent from the general to the special. The author begins with cosmical geology, i. e., the relation of the earth to other members of the solar system, a section of geology which has usually been relegated rather to astronomy, but which the late Alexander Winchell, in America, and others, mainly of England, have brought forward as one of the legitimate fields for the geologist to traverse and exploit. Through geognosy the author then descends to a more special examination of the chemical and physical forces that have produced the geologic changes which are embraced broadly under physical geography, and then enters upon an actual determination of the stratigraphic succession, the sources of the various rock masses, their different positions and relations. This eventuates in paleontological geology, involving a study of successive organic forms, and hence in historical geology. These facts being set forth in sufficient detail, and with sufficient discussion of differing views, the last step is to apply the laws deduced to the explanation of the present immediate surface and contour of the earth—this branch being physiographical geology, involving the causes of the surface phenomena, such as ocean basins, plains, valleys and mountains. Thus, from the remote and general the author descends by an easy and even a graceful logical sequence to the present and special. It is a philosophical sequence of topics, without making any prominent pretense at such succession.

The second characteristic is its familiarity with present American authorities, and its frequent citation of authors by copious foot-notes. The former characteristic adapts the work to a miscellaneous class of general students, making it a book that *can be read*, while the latter commends it to the working geologist and the enquiring and studious teacher. It is preëminently adapted to English-speaking geologists, and again especially to American geologists.

The author inculcates his views, when he reveals them at all as his own, by a judicious selection of authorities. He is apparently not a strict uniformitarian, nor is he a catastrophist. He mentions several considerations which conspire to indicate that in the early part of the earth's history as an individual in the solar system, even within the time of sedimentary accumulation, geological forces were much more effective and intense than they are now; at the same time he allows that the surface phenomena produced, owing to the present greater rigidity of those parts most likely to present legible results of the same forces, are greater than in the earlier part of sedimentary geology.

He presents briefly the data and the reasoning of geologists and of physicists for the age of the earth. He intimates that the physicists have probably overstated their case, in limiting the duration of geological time to fifteen or twenty million of years, and is inclined to consider the period of about 100 millions of years as none too long. This not only agrees approximately with the results originally announced by Lord Kelvin, in England, but also with results more lately reached by de Lapparent, in France, and Upham and Walcott, in America, as well as by Reade, in England.

The chapters devoted to the characters of minerals and of rocks, megascopic and microscopic, and to the classification of rocks, are well arranged and well illustrated. The general classification of the microscopic structures of rocks is that first proposed by Zirkel, viz.: holocrystalline, hemi-crystalline, glassy and clastic. The subdivisions, and some of the special terms are adopted from Fouqué and Michel-Levy, and from Rosenbusch. The massive crystalline rocks are divided chemically into three series, viz.: acid, intermediate and basic, and condensed descriptions are given of the various species belonging to each. Their division into two groups by Fouqué and Michel-Levy based on two successive stages of crystallization, and into three, based on their internal micro-structure, viz.: granular, porphyritic and glassy, or holocrystalline, crystalline and vitreous, are mentioned, but the author adopts the threefold division based on the relative amounts of silica.

The schistose crystalline rocks, i. e. the metamorphic, are derivable both from sedimentary strata and from igneous rocks. "At one end of the schistose series we find rocks in which an original sedimentary character remains unmistakable. At the other end, after many intermediate stages, we encounter thoroughly amorphous crystalline masses that bear the closest resemblance to eruptive rocks into which they insensibly pass."

The treatment of igneous rocks and of their relations to the strata with which they come into contact is one that shows the special qualifications of the author. The igneous rocks of all ages, as seen in Britain, have been the object of long study by him. These and the crystalline schists we do not think have been so thoroughly treated in any other similar work. In this excellent presentation we notice but two points to which as American geologists we feel like taking exceptions, viz.: There is no adequate allowance for internal heat of the earth as a cause for regional metamorphism. It seems more than probable that in at least Archean time the isothermal planes of mineral-changing heat ran nearer the surface of the earth, and that the early sediments, whether of chemical or fragmental origin, and especially if volcanic débris was mingled with them, would receive through their aid largely the mineral transformations which mark now the Archean crystalline schists. It also seems probable that these planes might vary for any given region from age to age, or between two regions, as to their actual nearness to the surface, thus producing crystalline schists at higher levels in some regions than in others. All these regional areas of metamorphism the author ascribes largely to dynamical agencies (including the presence of moisture), but he also points out their close alliance in their metamorphic phenomena with the areas that can be ascribed to contact metamorphism.

The second point to which we would take exception here is the quotation of the work of Dana and Wing on the metamorphic changes that can be traced out in the region of western New England between Vermont and New York city (p. 628). The author follows the old opinion of Prof. Dana that the schists concerned are of Trenton and Hudson

River age, and not of Taconic age. Since Prof. Dana's field work was published, not only have the quartzyte and the limestone and shales which he discussed been found to contain a Taconic fauna (Olenellus, etc.), but they have been found to pass into schists and gneisses. The original contention of Dr. Emmons as to the age of these metamorphic rocks has been abundantly verified. Again, Dr. G. H. Williams has also shown that the augitic, hornblendic and chrysolitic zones, supposed to have been produced by metamorphism in the sedimentary rocks, are true basic eruptions that invaded the Taconic strata probably prior to the commencement of the Lower Silurian, and have nothing to do with the original strata in age nor otherwise except to have modified them by contact.

In treating of the Glacial period, the author confidently attributes the glacial and modified drift to the action of vast sheets of land ice, without important aid from marine submergence, icebergs, and floes. Previous to the ice accumulation the altitude of the glaciated countries is thought to have been generally somewhat higher, or at least not lower, in relation to the sea level, than now. While the lands were ice-covered they are shown to have been somewhat depressed, allowing the formation of marine shore-lines and fossiliferous sea deposits upon the glacial drift after the retreat of the ice; but the submergence thus indicated nowhere exceeds 500 or 600 feet, as in the St. Lawrence valley and in Scandinavia. For some parts of Great Britain a probable submergence of about 500 feet is claimed, though the highest well defined marine terraces and beaches cited are only about 100 feet above the sea. The mass of stratified clay with marine shells enclosed in the till at the hight of 524 feet at Chapelhall in Lanarkshire, and the shell-bearing drift sand and gravel at greater hights, up to 1200 and 1350 feet, respectively, in Cheshire and on Moel Tryfaen in northern Wales, are regarded as more probably due to glacial transportation from the bed of the Irish sea than to the presence of the ocean at those altitudes.

The lower and upper deposits of boulder-clay or till, which are generally distinguishable over the greater part of the drift-bearing area of Europe, are ascribed to successive glacial epochs, divided by an interglacial time of general disappearance of the ice-sheets and prevalence of a mild climate, as known in some localities by the preservation of traces of the interglacial fauna and flora. But in view of the recent discussions and diverse interpretations of the evidences of such changes in America, the author leaves it an open question whether the Ice age shall be considered so distinctly twofold or multifold as the upholders of the astronomic theory of the causes of the glacial climate have taught. His reference of the outermost and next succeeding moraines of southern New England and Long Islond to "distinct and perhaps widely separated epochs in the Ice age" differs from the present views of most or probably all American glacialists. Not only these moraines, but also others described by Tarr and Hitchcock farther north in New England, the fifteen or more approximately parallel moraines traced by

Chamberlin and Leverett through Ohio, Indiana, and Illinois, and the nearly equal number described by Winchell and Upham in Minnesota, with their continuation west and northwest through the Dakotas and Manitoba, are doubtless referable to closely successive stages of halt or slight re-advance interrupting the recession of the ice-sheet at the end of the Glacial period. A similar series of retreatal moraines, already partially known, will probably be found traceable across northern Germany, northwestern Russia, southeastern Sweden, and Finland.

Concerning the question whether the drift was carried forward chiefly beneath the ice-sheet or within its basal part, in the latter case becoming exposed on the surface near the ice-front by ablation, especially during the glacial retreat, the author presents only or mainly the hypothesis of subglacial transportation, while in this country englacial and finally superglacial transportation of much of the drift has been long maintained by Dana and many others. We also note that the loess is attributed chiefly to wind action, which appears true for portions of Asia; but the development of this formation in America, where it extends along the course of the Missouri and Mississippi rivers, is very certainly due to deposition by broad river floods and lakes attending the departure of the ice-sheet. In Scotland the explanation recently given by Jamieson for the Parallel Roads of Glen Roy, that they were shores of lakes dammed by the waning Scottish ice-sheet, should probably take the place of the old hypothesis of obstruction by local valley glaciers, which is here retained. Again, in seeking the causes of the glacial climate, only Dr. James Croll's astronomical theory is adequately stated, and no space is given to the explanation by high uplifts of the lands that became ice-enveloped, which now is held to be most probable by nearly all American geologists, excepting those who think that some hitherto unsuggested cause remains to be discovered. It is mentioned, however, that Hutton accounts for the ancient glaciation of New Zealand by such a high epierogenic uplift.

The strange history of the Ice age, the descriptions of its records in all drift-covered regions, and the explanations of the origin of the widely varied drift formations, are very amply, clearly and interestingly presented by this magnificent text-book. It was quite impracticable and needless, in a science so broad and now receiving so thorough and critical investigation, to notice every phase of differing theories and opinions, or to bring the presentation in all cases exactly up to the present condition of knowledge.

Notwithstanding the foregoing criticisms, we consider the work of Dr. Geikie, like Agamemnon among his warriors, "conspicuous among his equals," and *par excellence* the best English text-book for American geologists.

Ueber das Silurgebiet des Bottnischen Meeres. By CARL WIMAN. (Bull. of the Geol. Inst. of Upsala, No. 1, vol. I, 1893.)

The earliest of the palaeozoic faunas represented in this region is a Cambrian sandstone with *Olenellus*, *Arionellus* and *Hyolithes*. This is followed by a very complete series of lower and middle Silurian beds, which, the author concludes, is nearer in its stratigraphical relations to the succession on the east coast of the Baltic than to that of Sweden (Öland and Dalarne).

Ueber Hypostomen von Homalonoten. By L. BEUSHAUSEN. (Jahrb. Königl. preuss. geolog. Landesanst. f. 1891, pp. 154-166, 1892.)

From the examination of the hypostomes of a few species representing some of the subgenera of *Homalonotus*, the author concludes that these plates do not show differentials of taxonomic value.

Sobre el Terreno Jurásico y Cretáceo en los Andes Argentinos entre el Rio Diamante y Rio Limay. By WILLIAM BODENSENDER. (Boletin Acad. Nac. de Ciencias de Córdoba, vol. XIII, pp. 5-47, 1892.)

A narrative of important geological investigations conducted by the author, with lists of fossils identified by Behrendsen in Zeitschr. deutsch. geol. Gesellsch., 1891-2.

Die Gebirgsformen in südwestlichen Kärnten, und ihre Entstehung. By FRITZ FRECH. (Zeitschr. der Gesellsch. für Erdkunde zu Berlin, vol. XXVII, pp. 349-390, 1892.)

A very instructive chapter on orogeny and geotectonics. The author discusses first the origin of the principal valleys, and secondly their modifications during the glacial and recent epochs. Under the latter heads are discussions of the extent of glaciation, and morainic distribution; of old and late glacial deposits; of the "Kare" and their origin ("under the term 'Kare' are included the cauldron-shaped niches below the mountain crest, which, behind and at the sides, are enclosed by steep walls, while the flat floor of the basin is open only at the front and there passes directly into a steep decline. In the summit Alps most of the 'Kare' are now filled with glacial ice and appear to be the birth places of the great glaciers"); of lakes due to glacial rotation and corrosion, and morainic damming; postglacial erosion and vale-making; catastrophic modifications, etc.

Das Rheinthal von Bingerbrück bei Lahnstein. By E. HOLZAPFEL. (Abhandl. Königl. preuss. geolog. Landesanst. Neue Folge, Heft 15, pp. 1-116, 16 plates, photogravures and half-tones, 1 map, 1893.)

Gives a detailed account of the geological structure of this classical region, with an especially important chapter on the classification of the Rhenish lower Devonian.

Die Jurabildungen des Kahlberges bei Echte. By JAMES PERRIN SMITH. (Inaugural Dissertation, 1893, pp. 1-72, 2 pl., 1 map.)

The Kahlberg is in north Germany, between Einbeck and the Hartz mountains. The author describes the geological succession of this region with some detail, giving special attention to the upper or white Jura, with comprehensive sections and lists of fossils. The palæontological part of the work includes descriptions of many new forms and concludes with a tabulated list of the fauna.

RECENT PUBLICATIONS.

I. Proceedings of Scientific Societies.

Bull. N. Y. State Museum, Vol. 3. No. 11, 1893, contains: Salt and gypsum industries of New York, F. J. H. Merrill.

Annals of the N. Y. Acad. Sci., Vol. 8, Nos. 1-3, 1893, contains: A study of the New York obelisk as a decayed boulder, A. A. Julien.

Proc. of the Boston Soc. of Nat. Hist., Vol. 26, Pt. 1, 1892-93, contains: The origin of drumlins, W. Upham; Remarks on drumlins, W. M. Davis; Remarks on drumlins, G. H. Barton; Indian quarries in Arkansas, L. S. Griswold; Deflected glacial striæ in Somerville, W. Upham; The Fishing Banks between Cape Cod and Newfoundland, W. Upham; Evidences of Man in Nicaragua, J. Crawford; Bioplastology and the related branches of biologic search, A. Hyatt; Traces of a fauna in the Cambridge slates, J. B. Woodworth.

Proc. Acad. Nat. Sci., Pt. 2, 1893, contains: Description of a lower jaw of Tetrabelodon shepardii, E. D. Cope; Cretaceous ammonites and other fossils near Moorestown, N. J.; Their stratigraphic position shown by an artesian well section at Maple Shade, N. J.; Incidental reference to water horizons, L. Woolman; Remarks on a new species of Cypræa, J. Ford; Notes on the physical geography of Texas, R. S. Tarr.

Jour. Cincinnati Soc. Nat. Hist., Vol. 15, No. 2, 1892, contains: The preservation of plants as fossils, J. F. James; Some new species and new structural parts of fossils, S. A. Miller and C. Faber; Manual of the paleontology of the Cincinnati group, J. F. James (Pt. III); Remarks on the stems and roots of crinoids near Lebanon, Ohio, D. T. D. Dyche.

Vol. 15, Nos. 3-4, 1892-93, contains: Manual of the paleontology of the Cincinnati group, J. F. James (Pt. IV); Microscopical study of Ohio limestones, G. P. Grimsley.

Vol. 16, Nos. 2-3, 1893, contains: Studies in problematic organisms. No. II—The genus Fucoides, J. F. James; Remarks on the genus Arthrophycus, Hall, J. F. James; Natural History notes from North Carolina, A. G. Wetherby; Fossil fungi, J. F. James.

Cal. Acad. Sci., Occasional papers, IV, 1893, contains: A classed and annotated bibliography of the Palæozoic Crustacea, 1698-1892, to which is added a catalogue of North American species, A. W. Vogdes.

Proc. Cal. Acad. Sci., Vol. 3, Pt. 2, 1893, contains: Geological surveys in the state of California, A. W. Vogdes.

Bull. Geol. Soc. of America, Vol. 5, Nov., 1893, contains: Proc. of the Fifth summer meeting, held at Madison, Aug. 15-16, 1893.

Proc. of the Biol. Soc. of Washington, Vol. 8, July, 1893, contains: The paleontology of the Cretaceous formations of Texas; The invertebrate fossils of the Caprina limestone beds, Robt. T. Hill.

II. Papers in Scientific Journals.

School of Mines Quarterly, Vol. XIV, No. 4, July 1893, contains: Notes on the Lower Coal Measures of Western Clearfield county, Pa.,

J. F. Kemp; The old Telegraph Mine. Bingham Cañon, Utah, C. Fenner.

The Glacialists' Magazine, Vol. I, No. 1, contains: On an Intrusive Mass of Boulder Clay, A. R. Dwerryhouse.

Jour. of Geol., Vol. 1, No. 6, Sept.-Oct., 1893, contains: Theory of the origin of mountain ranges, J. LeConte; On the migration of material during the metamorphism of rock masses, A. Harker; The Cordilleran Mesozoic revolution, A. C. Lawson; Sketch of the present state of knowledge concerning the basic massive rocks of the lake Superior region, W. S. Bayley; A study of consanguinity of eruptive rocks, O. A. Derby; A dissected volcano of Crandall basin, Wyoming, J. P. Iddings; Notes on the lead and zinc deposits of the Mississippi valley and the origin of the ores, A. Winslow.

Amer. Jour. Sci., Vol. 46, Nov., 1893, contains: New England and the upper Mississippi basin in the Glacial period, J. D. Dana; Use of the name "Catskill," J. J. Stevenson; Finite elastic stress-strain function, G. F. Becker; Powellite from a new locality, G. A. Koenig and L. L. Hubbard; Geology and petrography of Conanicut Island, R. I., L. V. Pirsson; Larval form of Triarthrus, C. E. Beecher; Rise of the mammalia in North America, H. F. Osborn; Description of Miocene mammalia, O. C. Marsh.

Kans. Univ. Quar., Vol. 2, No. 2, Oct., 1893, contains: Kansas pterodactyls (II), S. W. Williston; Kansas Mosasaurs, S. W. Williston.

Amer. Naturalist, Vol. 27, Sept., 1893, contains: On the structure of the carapace in the Devonian crustacean Rhinocaris, and the relation of the genus to Mesothyra and the Phyllocarida, J. M. Clarke.

Vol. 27, Oct., 1893, contains: Phylogeny of an acquired characteristic, A. Hyatt.

Canadian Record of Science, Vol. 5, No. 7, 1893, contains: Are the Great Lakes retaining their ancient level? Commander J. G. Boulton; Geological notes, Sir J. W. Dawson; Notes of a great silver camp, W. A, Carlyle.

III. Excerpts and Individual Publications.

Hatch's Notes on the Birds of Minnesota, T. S. R. "The Auk," July, 1893.

A Catalogue of the Official Geological Surveys of the State of California, Anthony W. Vogdes, Extr. Proc. Cal. Acad. Sci., Vol. III, 1893.

Alnoite containing an uncommon variety of Melilite, C. H. Smyth, Jr., Am. Jour. Sci., Vol. XLVI, Aug., 1893.

Two Neocene Rivers of California, W. Lindgren, Bull. Geol. Soc. of America, Vol. 4, pp. 257-298.

Certain Dissimilar Occurrences of Gold-bearing Quartz, T. A. Rickard. Read before the Colorado Scientific Society in Denver, Sept. 4, 1893.

On the Cyclopidæ and Calanidæ of Central Wisconsin. C. D. Marsh. Reprint from Vol. IX of the Trans. of the Wis. Acad. Sciences, June, 1892.

Report on the Colorado Coal Field of Texas, N. F. Drake and R. A.

Thompson. Extract from Fourth Annual Report of Geol. Surv. of Texas, 1893.

Report on the Cretaceous Area North of the Colorado River, J. A. Taff. Extract from Fourth Annual Report of Geol. Sur. of Texas. 1893.

Quicksilver Ore Deposits with Statistical Tables, G. F. Becker. Extr. from "Mineral Resources of the U. S. for 1892."

The origin of the crystalline schists of the Malvern Hills, C. Callaway. Quar. Jour. Geol. Soc., Vol. 49, 1893.

The seiche in America, E. A. Perkins, Amer. Meteor. Jour., Oct., 1893.

The improvement of geographical teaching, W. M. Davis, Nat. Geog. Magazine, Vol. 5, 1893.

IV. Foreign Publications.

Memoire della R. Accademia delle Scienze dell' istituto di Bologna, Serie V, Toma II, contains: Terzo contributo alla conoscenza della microfauna terziaria italiana, C. Fornasini; Fossili retici della Montagna di Cetona, V. Simonelli.

Annual Report of the Department of Mines and Agriculture, New South Wales, for the year 1892.

Bulletin de la Société Géologique de France, 3rd Serie, t. XX, No. 5, 1892, contains: Note sur les Poissons du terrain Permien de l'Allier, H. E. Sauvage; Etude sur les Ammonites des étages moyens du système jurassique, E. Haug; Sur la géologie du Chablais, M. Lugeon.

No. 7, 1892 contains: Sur les terrains crétacés du massif de Bou-Thateb, E. Ficheur; Sur la découverte du Palæonictis en Amérique, M. Osborn; Sur le comblement des lacs pyrénéens, M. E. Belloc; Sur les plissements des couches sédimentaires dans les environs de Poitiers, J. Welsch.

T. XXI, No. 1, 1893, contains: Le Ligurien et le Tongrien en Egypte Meyer,Eymar; Coup-d'œil sur les eaux thermales des régions mésozoiques du Portugal, P. Choffat.

Compte-Rendu des Seances de la Société Géologique de France, No. 13, June, 1893.

On the Dwindling and Disappearance of Limestones, F. Rutley, Quar. Jour. of the Geol. Society, Vol. XLIX, Aug., 1893.

Catalogue of Type Fossils in the Manchester Museum, Owens College.

Description of some new Birds collected on the Islands of Aldabra and Assumption, Northwest of Madagascar, by Dr. W. L. Abbott, Robt. Ridgway, Proc. Nat'l Museum, Vol. XVI, No. 953, Aug. 1893.

Bulletin de la Société des Sciences Naturelles de L'ouest de la France, T. 3, No. 1, 1893, contains: Recolte et la preparation des Cephalopodes, M. L. Joubin.

Zeit. für prakt. Geologie, Heft 8, Jahr. 1893, Aug., 1893, contains: Die Form der Eisenerzlagerstatten in Huttenberg, A. Brunlechner; Das Erzvorkommen von Cinque-valle bei Roncegno in Sudtirol, J. Haberfelner; Die Erzgange von Pontgibaud, M. Lodin.

V. Proceedings of Scientific Laboratories.

Bull. of the Department of Geology, Univ. of Cal., contains: The Geology of Carmelo Bay, A. C. Lawson; The Soda-Rhyolite north of Berkeley, Chas. Palache.

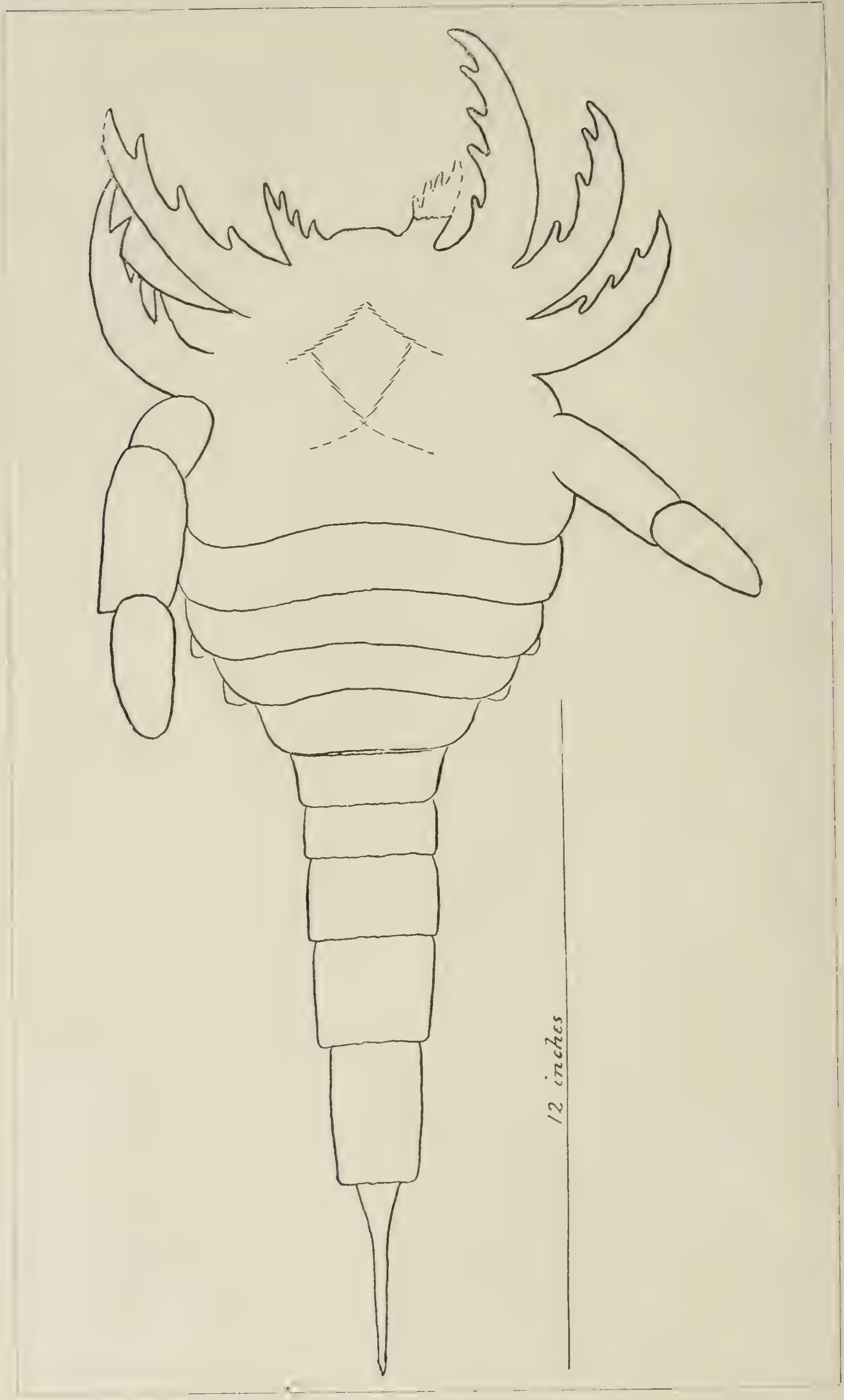
PERSONAL AND SCIENTIFIC NEWS.

Henry William Crosskey, LL. D., F. G. S.—In the death of Rev. Henry William Crosskey, who died Oct. 1, 1893, at the age of 67, the world loses at once a fruitful worker in various lines of scientific investigation, a profound theologian, and a courteous Christian gentleman. At the time of his death Mr. Crosskey had been for many years pastor of the Unitarian church in Birmingham, England, over which Priestley was pastor at the time of his discovery of oxygen. Dr. Crosskey has well maintained the scientific reputation of the pastorate so brilliantly begun by Priestley. Dr. Crosskey was high authority on the geology of the glacial epoch, being specially well versed in the marine fossils pertaining to the epoch. He had published frequent communications upon the subject in the Transactions of the Geological Society of Glasgow, the Proceedings of the Birmingham Philosophical Society, and in other places. He has been for some time a member of the Boulder Committee of the British Association, and was active in promoting the interest of the Northwest of England Boulder Committee. His interest was to such an extent enlisted in professor H. Carvill Lewis's glacial investigations in England that after Lewis's death he carefully edited his field notes which Mrs. Lewis is soon to publish. Dr. Crosskey's health suddenly failed something over a year ago; but after a prolonged stay on the continent, he returned to his work apparently much improved. The appearance, however, was deceptive, and the end came sooner than was expected; but he has left his permanent mark upon the discussions relating to one of the most absorbing subjects of scientific investigation.

At the meeting of the Minnesota Academy of Natural Sciences, held December 26th, the following papers were presented: 1. Preliminary remarks on the rodent *Dipodomys ordii*, by the President, Dr. H. L. Osborn. 2. Notes on the anorthosites of northeastern Minnesota, by Mr. A. H. Elftman. These rocks, with the exception of those at Carlton peak, described by Lawson (Bull. No. 8, Geol. and Nat. Hist. Survey of Minn.), were stated to be entirely detached fragments, often of enormous size, imbedded in the Keweenawan lavas, and as such they are not in place and consequently do not represent the floor on which the Keweenawan lavas flowed, and so give no evidence as to the thickness of this series. 3. Evolutionary development in some species of Brachiopoda, by Mr. F. W. Sardeson. The development of some forms in the Lower Silurian of the Upper Mississippi valley was discussed; it was stated that certain species and varieties retained their characters and extended through a considerable number of beds, although sometimes absent from one or more beds, but reappearing again higher up. The different species and varieties do not vary into other forms nearly as often as has been stated by others.

DISCOVERY OF AN EGG OF THE ÆPYORNIS.—A large specimen of the egg of the fabled "roc" of the "Arabian Nights," or *Æpyornis*, as the extinct gigantic bird of Madagascar is called, has recently been secured by Mr. J. Proctor, of Tamatave and London. It was discovered by some natives about twenty miles to the southward of St. Augustine's bay, on the southwest coast of Madagascar. It was floating on the calm sea, within twenty yards of the beach, and is supposed to have been washed away with the foreshore, which consists of sandhills, after a hurricane in the early part of the year. The child-like longshoremen of the antipodes, thinking that the egg might have a value, showed the unusual piece of flotsam about, with a view to the sale of it, and it thus came into the hands of Mr. Proctor who has brought the curiosity to London. The egg, which is whitish-brown in color and unbroken, is a fine specimen, 33½ inches by 28 inches, and an even higher value is placed upon it than upon the egg of the great auk, which lived within the memory of man. The Brobdignagian proportions of the egg are better demonstrated by comparison with the eggs of the ostrich and crocodile. An ostrich's egg is about 17 inches by 15 inches, and the contents of six such are only equal to one egg of the *Æypornis.* The measurements of the egg of the crocodile are normally 9 inches by 6½ inches. It would require the contents of 16½ emu's eggs to equal the contents of this great egg, or 148 eggs of the homely fowl, or 30,000 of the humming bird. The last egg of the kind disposed of in London sold for £100, though cracked.—*Scientific American.*

AT A LATE MEETING OF THE GEOLOGICAL SOCIETY of Washington the following officers were elected for the ensuing year: President, C. D. Walcott; vice-presidents, S. F. Emmons, G. K. Gilbert; treasurer, Arnold Hague; secretaries, J. S. Diller, Whitman Cross; council, G. F. Becker, G. P. Merrill, R. T. Hill, C. Willard Hayes and W. H. Dall. The society has 134 members, 22 being corresponding members. During the past year there has been an average attendance at the meetings of 36.



CARCINOSOMA (EURYSOMA) INGENS Claypole.

THE

AMERICAN GEOLOGIST

VOL. XIII. FEBRUARY, 1894. No. 2.

[PALEONTOLOGICAL NOTES FROM BUCHTEL COLLEGE.—NO. 6.]

A NEW SPECIES OF CARCINOSOMA.

By E. W. CLAYPOLE, Akron, O.

In the AMERICAN GEOLOGIST for October, 1890, I described and figured a new genus and species of crustacean from the Water-lime quarries at Kokomo, Indiana. That fossil differed in some characters from all known forms of its class. These characters are well shown even in the crushed and flattened condition in which the specimen occurred. It is merely a black film on the surface of the slab, in this respect resembling those from the same horizon at Buffalo and elsewhere.

A few weeks ago Mr. Charles Smith, of Akron, O., obtained from his brother, residing at Kokomo, a slab of the Water-lime rock, showing an excellent outline of a crustacean evidently closely allied to the above, but of much larger size. Through his kindness I have been allowed to make a drawing of the specimen and to describe it for the AMERICAN GEOLOGIST.

The former specimen was described under the generic name of Eurysoma, but after the paper containing it had appeared I learned from a friend that this word had been preoccupied in Europe. Hence it became necessary to change it, and in the December number of the magazine I substituted the name Carcinosoma (p. 400).

Carcinosoma ingens, sp. n.

The generic description remains unchanged in every important point, but the present specimen being preserved with the ventral surface exposed, shows some specific details which were invisible in the former.

In the specific description the leading points of difference and those on which the definition rests are the greater size of the fossil and the smaller number of cusps or branches on the four anterior pairs of gnathopods.

The specimen measures twenty-four inches in length, whereas none of those from which the description of *C. newlini* was compiled exceeded fourteen. There are also only three cusps on the front edge of the first, third and fourth pairs of gnathopods, and four on the second pair. In *C. newlini* these cusps are sometimes eight to twelve in number, and apparently in some cases project from the back of that organ, though this must be considered uncertain and against analogy.

There is, moreover, on the large paddles no trace of the fringed or serrated edges* which are so conspicuous in the paddles of *C. newlini*. They are perfectly even and smooth.

There are also some marginal projections on the hinder part of the cephalo-thorax which may be the traces of abdominal appendages, or they may be merely the projecting margins of their corresponding somites, jutting out beyond the general line of the body.

No markings of any kind can be made out on the surface of the body such as the crescentic sculpture on the carapace of Eurypterus. This may, however, be due to the roughness of the limestone matrix.

The genus Carcinosoma appears to be intermediate among several of the other previously known genera of crustaceans from this horizon. It has the long, spiny tail of Stylonurus and its branched gnathopods, the large fifth pair of appendages of Pterygotus, the wide, short body of Limulus or of the limuloids of that time, and the four small anterior pairs of appendages of Eurypterus. Its nearest ally is apparently Eusarcus† of Grote and Pitt, described in the Bulletin of the Society of Natural Sciences (Vol. III, No. 1). But the description of that genus mentions that the cephalo-thoracic portion

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*Misprinted "eyes" in the original description, p. 260, AMERICAN GEOLOGIST, 1890.

†In Miller's Catalogue of Palæozoic Fossils this is put down as a synonym of Eurypterus, but the distinctions are quite sufficient to warrant generic separation.

is considerably narrower than in allied forms and that the terminal segment shows a widening and no trace of spiniform process. There are also several other minor points of difference.

But except its outward form or outline the above described fossil tells us nothing about the details beyond what was known before, unless the indistinct outline of a metastomatic plate may be so regarded. This is a quadrilateral rhombic area, a little in front of the central part of the body, margined by four furrows and corresponding to a similar area visible in some specimens of Eurypterus which show the ventral aspect.

ON THE GEOLOGICAL POSITION OF BENNETTITES DACOTENSIS MACBRIDE, WITH REMARKS ON THE STRATIGRAPHY OF THE REGION IN WHICH THE SPECIES WAS DISCOVERED.

By SAMUEL CALVIN, Iowa City, Iowa.

Since professor Macbride's paper on *Bennettites dacotensis* was published in the AMERICAN GEOLOGIST for October, 1893, there have been numerous inquiries respecting the exact geological horizon from which the cycads were derived. The close resemblance and the intimate relationship indicated between the Dakota fossil and *Tysonia marylandica* Fontaine, while not conclusive, would yet point toward a common horizon for the two species, and so make it possible to correlate the Potomac formation with a definite Mesozoic horizon in the Northwest. Professor Macbride's paper left the stratigraphical position of his species undecided. To settle the question definitely, if possible, the writer recently made a visit to the locality that furnished the types of Macbride's species.

Specimens of Bennettites are not very numerous in the Black Hills of South Dakota. At all events not very many have yet been brought to light. All the individuals at present known have been found in a rather limited area around Minnekahta, a small station on the Deadwood branch of the B. & M. railway. By far the greater number, some forty or fifty altogether, were discovered on an area of only a few acres about four or five miles southwest of Minnekahta. They all lay, partly imbedded in the soil, on the southern slope of one of the low, rounded, grassy hills that characterize the marginal portion of the Black Hills uplift. Separating the cycad hill from the next on the south is a comparatively shallow but steep-sided cañon, supporting a comparatively dense growth of *Pinus ponderosa* Douglas. The walls of the cañon reveal the edges of gently folded and tilted beds of sandstone. Sandstones—yellow, brown, or red, sometimes in massive and sometimes in thinner layers—often project above the grassy surface on the gentler slopes above the cañon walls; while here and there are high buttes, rising two or three hundred feet above the general level, and composed of conformable beds of sandstone throughout their entire elevation. A single sandstone formation, therefore, extends from the bottom of the small secondary cañons of the region to the top of the buttes, and, though no cycads were seen in place, there is no reason to doubt that it was in this sandstone, at some level, that they were originally imbedded. The sandstone exhibits the characteristics of the Dakota group of the Black Hills as described by Hayden, Winchell and Newton, still it was thought best not to decide the question of its age on lithological grounds alone. Diligent search during the short time at our disposal failed to disclose the remains of recognizable plants or animals, belonging to the sandstone, in place. Fragments of silicified trunks, probably of deciduous trees, lay loose on the surface. Some of these were mingled with the cycad trunks, and, since the condition of mineralization was the same in both, it was inferred that the silicified trunks of both types had been imbedded under the same conditions and that they probably came from the same horizon. A short distance east of the cycad field a gray shale, supposed to be the Jurassic of the geologists who have written on the Black Hills, was revealed by an upward arching fold in the bottom of the cañon, but, as it contained no fossils, judgment was for the time reserved. Three or four miles west of the main group of cycads ash-colored shales, recognized beyond a doubt by *Belemnites densus* and other characteristic fossils as the Black Hills "Jurassic," are exposed in full force in the east side of Big Horn basin. The whole thickness of the Jurassic, two hundred feet or more, is thus revealed: while beneath the Jurassic shales, at the bottom of the basin-like valley, there is an exposure of Red Beds having a thickness of twenty or thirty feet. The rim of Big Horn basin, on the east side at least, exhibits ten or twelve feet of heavy, cross-bedded sandstone resting directly on the Jurassic shales. These cross-bedded layers constitute the base of the great sandstone formation to which reference has already been made. The formation extends from the Jurassic shales to the summits of the adjacent buttes. On stratigraphical evidence we are now prepared to recognize it as the Dakota sandstone. The cycad beds are therefore Cretaceous and belong to Meek and Hayden's Cretaceous No. 1.

A considerable thickness of the sandstone at the top of all the higher buttes of the region has been converted into a very hard, brittle quartzite. The process of vitrification has in some instances almost completely obliterated the original structure; in other cases the original sand grains are seen imbedded in a secondary deposit of silica. Contrary to the opinion of some observers, I believe the vitrification to be due to conditions that existed in the sea at the time the beds were deposited. The waters were charged with an unusual amount of soluble silica which was not only precipitated among the sand grains, converting the whole mass into a homogeneous quartzite, but some of it was substituted for the molecules of lignified and other tissues in the stems of cycads and deciduous trees that by accident were floated in from adjacent lands.

The silicified trunks of ordinary trees now found on the lower slopes occupied by the sandstone are very much broken and weathered and polished by long exposure. On the shoulder of one of the buttes, a mile or two west of the main cycad field, not far below the level of the vitrified bed, there was noted a silicified log two feet in diameter at the base, twelve feet of the basal part unbroken, and a train of fragments of varying dimensions extending from the smaller end far enough to indicate an original length of seventy or eighty feet. The fresh appearance of this specimen with its fractures sharp-angled and its parts of considerable length all in their natural relative positions, was in striking contrast with the short, polished, worn, disassociated fragments found in the residual soil on surfaces two or three hundred feet lower. The differences in condition and appearance indicate enormous differences in the length of time the specimens have been exposed. The effects on the better preserved specimen of rain and frost and wind-driven sands, with frequent falls from undermining cliffs, during the years necessary to reduce the hill on which it lies to the level now occupied by the fragments with which it is compared, will not be left to conjecture so long as the worn and dismembered fragments lying at lower levels remain to furnish objective illustrations of what those effects have been in the past. There are reasons for the conclusion that all the silicified trunks, including those of Bennettites, came from the same horizon and that that horizon was the vitrified beds near the summit of the Dakota sandstone.

East of the valley followed in this vicinity by the B. & M. railway, rises Arnold's peak, a high butte, the summit eight hundred feet above the valley, and, like the other high points of the region, capped with vitrified sandstone. The geological structure at the base is concealed, but a mile or two farther north, almost directly east of Minnekahta, the ridge of which Arnold's peak is simply the most prominent part, reveals at its base the belemnite-bearing beds of the Jurassic. The plain on which Minnekahta stands is some scores of feet below the top of the Jurassic and not less than six hundred feet below the vitrified sandstone near the summit of the Dakota group. On this plain a few specimens of Bennettites have been found, but in most cases they were so far decomposed as to fall to pieces when attempts were made to remove them. Again we find some relation between the abrasion and decomposition that the fossils have undergone and the vertical distance they lie beneath the vitrified beds. Assuming that all the fossils were imbedded at essentially the same horizon, then those that now occupy the lowest level have been longest exposed to atmospheric and aqueous agencies.

At Hot Springs,—about twenty miles, as one has to travel, from the principal group of cycads,—the valley of Fall river has been cut down through the entire thickness of the Dakota sandstone, through all the Jurassic, and down into the purple limestone and gypsiferous red clays of the Red Beds. Battle mountain, east of the town of Hot Springs, has an elevation of about a thousand feet above the valley. The upper part of the mountain is composed of Dakota sandstone, and away up at the summit is the quartzite seen on the higher eminences around Minnekahta. Fall river, formerly known as Minnekahta creek, flows off toward the southeast to join the south fork of the Cheyenne river. About four miles from Hot Springs the stream emerges from the sandstone hills in a series of cascades which constitute the falls of Fall river. At the falls, as previously observed by Newton, the sandstone is inclined at a high angle and passes beneath the dark colored shales of the Fort Benton group. Crossing the nearly level plain that separates the last of the sandstone hills from a high escarpment that curves around nearly parallel to the margin of the uplift, we find ourselves on calcareous beds of the Niobrara group. These beds are charged with *Inoceramus problematicus* Schlot., with occasional colonies of *Ostrea congesta*, the whole aspect of the formation resembling closely the Inoceramus-bearing beds near Sioux City, Iowa, and Ponca, Nebraska. The similarity of the Sioux City deposits to Niobrara beds on French creek, a locality probably thirty miles northeast of the point just noted was remarked by Prof. N. H. Winchell in 1874.

Over on the Cheyenne river, about six miles east of Fall river falls, is an exposure of Niobrara that reminds one of the massive chalk beds at St. Helena, Nebraska. The resemblance is not complete, for at St. Helena the beds are for the most part white, only occasionally portions are bluish in color, owing to the presence of organic matter. On the Cheyenne the beds are all bluish. They give out a strong fœtid odor when struck with the hammer. There are indications of the presence of organic matter in unusual amount. But the massive bedding of the soft, calcareous material, the manner in which the layers break down, the great angular blocks of talus, the occasional small colonies of *Ostrea congesta*, the vertebræ and scales of fishes, are each and all perfectly duplicated at the two points mentioned—namely, on the Missouri at St. Helena and on the south fork of the Cheyenne southeast of Hot Springs.

Around Edgemont, south of the Hills, the country for some distance is occupied by the Fort Benton shales. A steep escarpment which constitutes the vertical face of the first terrace south of the Cheyenne, reveals, with their usual characteristics, the Inoceramus beds of the Niobrara; but passing on southwest over the hills toward the valley of Cottonwood creek, the Fort Benton is again exposed. Erosion of the shales has formed a series of Bad Lands on a diminutive scale. It has at the same time made prominent certain beds of impure limestone from which we obtained numerous fossils. Among the material collected here were specimens of *Prionocyclus wyomingensis* Meek, *Scaphites warreni* Meek, *S. wyomingensis* Meek, *Lunatia concinna* M. & H., *Inoceramus pseudo-mytiloides* Schiel, two or three other species of Inoceramus, a Pteria or two, and many other less obtrusive forms that have not yet been identified.

At the town of Hot Springs some portions of the valley are occupied by horizontal beds of a very coarse conglomerate that lies unconformably on the folded and tilted Red Beds. The thickness of the conglomerate is about forty feet. It is composed of fragments of all the harder formations from the crystalline rocks at the center of the uplift to the purple limestone of the Red Beds, and the quartzite of the Cretaceous. When the conglomerate was deposited the valley had essentially its present depth. In some cases the streams have just fairly completed the work of cutting through the conglomerate, in other cases they have cut twenty or thirty feet below its base. This conglomerate is probably the equivalent of that lying at the base of the White River Miocene. If so, it would indicate an enormous amount of erosion between the beginning and middle of the Tertiary as compared with the amount accomplished since.

Returning finally to the main object for which these observations were undertaken, it is clear that *Bennettites dacotensis* Macbride belongs to the Cretaceous period, and the evidence is practically conclusive that the exact horizon at which the individuals of the species were imbedded is represented by the uppermost layers of the Dakota sandstone.

INTERGLACIAL FOSSILS FROM THE DON VALLEY, TORONTO.

By A. P. Coleman, Ph. D., Prof. Met. and Assaying, School Pract. Sc., Toronto.

Fossils have been reported from a number of localities in the drift deposits of Ontario, those from the extreme east of the province being chiefly subarctic marine forms, while the species occurring in the center and west are mainly fossil land plants and freshwater shells with a few remains of deer, beaver and mastodon. Among the more important publications in which the Ontario drift fossils are referred to may be mentioned two papers by Prof. Chapman in the Journals of the Canadian Institute,[*] a paper by G. J. Hinde in the same journal,[†] a paper by Dr. R. Bell in the Canadian Naturalist and Geologist,[‡] and the account of the superficial geology of Canada in the Geological Survey Report for 1863.[§] In this report our superficial deposits are classified as follows:

2. { Algoma sand.
Artemisia gravel.
Saugeen freshwater clay and sand. }
1. Erie clay.

It is difficult to distinguish these deposits from one another in many cases, and there are such wide local variations that the classification is not always of value. Where the horizon of drift fossils is mentioned, they are generally referred to the Saugeen clay and its associated sandy beds or to the sands of raised beaches of postglacial formation. In most recorded instances the exact geological horizon of the find has not been determined, and the fossils may have come from postglacial rather than interglacial deposits. The only cases of undoubted interglacial fossils which I have seen reported are from Niagara Falls, where Cyclas was found in a sandy loam containing striated pebbles,[||] and from Scarboro' Hights,[**] a few miles east of Toronto, where Mr. Hinde found three distinct layers of till with fossiliferous beds of sand and clay between the two lower ones. From these beds Mr. Hinde obtained three species of diatoms, a Chara, five mosses, spores of Lycopodium, pieces of pine and cedar wood, portions of leaves of rush, etc., and seeds of various plants; as well as two or three species of Cypris, the elytra of a carabid, a Planorbis, a Zonites (doubtful),—in all a respectable little flora and fauna.

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[*] Vol. vi, pp. 221 and 497, etc.

[†] Vol. xv, p. 388, etc.

[‡] Feb., 1861, p. 42, etc.

[§] Vol. for 1863, p. 886, etc.

[||] Geol. Sur. Can., 1863, p. 902.

[**] Glacial and Interglacial Strata of Scarboro' Hights. Jour. Can. Inst. Vol. xv, p. 388, etc.

Fossils have been found frequently in the drift near Toronto. Prof. Hinde mentions the finding of trunks and branches of trees imbedded in the overlying yellow clay at depths of from ten to twenty feet below the surface;* and from the Don valley in the eastern part of the city pieces of half carbonized wood, and fragments of shells have been collected from time to time. They are first mentioned by Prof. Chapman† and Dr. Bell,‡ in 1861, who note the fact that a Melania and Unio ellipsis had been found by Dr. B. Workman under a deposit of sand about 30 feet above the lake.

While excavations were in progress for the straightening and embanking of the Don numerous fossils were obtained on the left bank of the river near the Gerrard street bridge, by Dr. Brodie and Mr. J. Townsend. Sir Wm. Dawson in 1890 refers to the finding of leaves, fragments of wood, and shells of Melania and Cyclas by the latter collector.§ In an appendix to the same paper Prof. Penhallow has figured a leaf found by Mr. Townsend, describing it as a new species under the name of Acer pleistocenicum.‖ He determined other specimens from the same locality as follows,—Asimina triloba, Ulmus racemosa, and Taxus baccata. Mr. Wm. Spry, who was engineer in charge of the work during part of the time, informs me that there were tree trunks one or two feet through in the boulder-clay just above the underlying shale at Jail hill somewhat north of the bridge.

Since then a cutting on the Belt Line railway near the Winchester street bridge, half a mile above the previous locality and the west side of the river, has afforded many very fragile specimens of Pleurocera, Valvata sincera and Sphærium striatinum, as well as pearly fragments of Unio. The fossiliferous bed is sandy and reaches about 25 to 35 feet above the Don.

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*Geol. Sur. Can., 1863, p. 904.

†Can. Jour., Vol. VI, p. 226.

‡Can. Nat. and Geol., Feb., 1861, p. 42.

§Bull. Geol. Soc. Am., Vol. I, p. 315.

‖Idem, p. 328.

The most interesting exposure of all has recently been opened at the Messrs. Taylors' brickyard, nearly a mile north of the Gerrard street bridge. Many specimens of Unio have been collected here by myself, Mr. Blue, Mr. Townsend and the workmen employed in the quarry. The majority of them are so fragile as to fall to pieces with even the most careful handling; and it was only after following the advice of Dr. Dall, of the Smithsonian Institution, to soak the fossils in shellac varnish diluted with alcohol, that they could be at all satisfactorily preserved.

My thanks are due to Dr. Dall and his aid, Mr. C. T. Simpson, for the determination of the specimens, which include the following species ,—Pleurocera subulare, P. elevatum, an undetermined species of the same genus and a single specimen which may be P. pallidum ; Valvata sincera, Sphærium striatinum, Unio phaseolus, U. clavus, U. pustulosus, U. pustulosus var. schoolcrafti, U. occidens (?), U. luteolus, U. undulatus, U. rectus, U. trigonus, U. solidus.

Mr. Simpson has described these fossils in the Proceedings of the U. S. National Museum* and states that at least three of the species of Unio and one Pleurocera are no longer inhabitants of the St. Lawrence drainage area, but belong to the waters draining into the Mississippi.

A list of the species now living in the vicinity of Toronto, made out for me by Dr. Brodie, includes only four of the species obtained at the quarry, viz. Valvata sincera, Sphærium striatinum, Unio luteolus and U. rectus. Specimens of the two Unios which he has sent me are thinner-shelled than the fossils of the same species.

Three specimens of wood obtained at the quarry just above the lower boulder-clay were forwarded to Prof. Penhallow, of McGill University, for examination. As his report is appended to this paper, it is sufficient to state at this point that he refers the specimens, which he finds badly decayed and crushed, provisionally to the nearest living species, Fraxinus quadrangulata, Quercus obtusiloba, and Taxus baccata, var.

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*Vol. XVI, pp. 591-595.

canadensis. The first two have not hitherto been reported from the Canadian drift.

In order to show definitely the geological horizon at which the fossils were found, the section exposed at Taylors' brickyard has been measured, giving the following results:

	Feet.
1. Sandy soil followed by brownish grey clay with boulders . . .	3
2. Stratified bluish grey clay (making buff brick).	69
3. Brownish or drab clay, much jointed (making red brick). . . .	11
4. Brownish yellow stratified sand	4
5. Blue clay with peaty flakes.	3
6. Brown sand and gravel (false bedding) with thin layers of blue or brown clay—fossiliferous.	18
7. Blue clay (till) with striated boulders.	3
8. Hudson River shales.	30
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The Hudson River shales, which are quarried to make dark red pressed brick, rise about 30 feet above the Don, here practically at the level of lake Ontario; and are covered with a thin layer of typical boulder-clay containing finely polished and scratched fragments of the under-lying Cambro-Silurian rocks with a few stones of Laurentian origin. The residue of the clay after washing discloses particles of quartz, hornblende, feldspar, etc., evidently derived from Archæan rocks.

From the upper portion of the clay, which is indistinctly stratified, I have obtained Unios and the specimens of wood submitted to Prof. Penhallow. The Unios had evidently lived in the place where they were found, since they were not at all waterworn, still preserved their dark epidermis and frequently had the two valves attached. The till fills up all inequalities in the previously eroded surface and forms a floor with a gentle southward slope under the whole city. To the south it passes beneath the surface of the lake at some points.

I am informed by Mr. B. E. Walker that in excavating for the foundations of the Board of Trade building a few years ago two shark's teeth, apparently of Tertiary age, were found in the till. One of them is now in his possession. It is hard to account for this find, since no Tertiary rocks are known to exist this side of Hudson's bay. Some small outlier may lie hidden under the drift or may have been completely swept away by ice action.

Above the till we find 18 feet of sand with some fine gravel and a few thin layers of clay, a deposit formed in shallow water with shifting currents as shown by the false bedding. Well rounded pebbles of Laurentian and Silurian rocks occur, and the sands contain fragments of most of the minerals belonging to Archæan rocks. Some layers are brown from a deposit of hydrous sesquioxide of iron. Shells of Pleurocera and Sphærium are common throughout the sand, and about eight feet above the till there is a layer containing many Unios, mostly separate valves more or less waterworn.

Above the sand is a bed of blue calcareous clay with flakes of peaty matter, then a bed of unfossiliferous sand, followed by a thick bed of distinctly jointed brownish clay, making red brick, probably corresponding to the Erie clay described in the Geological Survey Report for 1863.

This is succeeded by 69 feet of finely stratified bluish grey clay too calcareous for brick-making in the lower portions but yielding a buff brick from the upper layers. Very few pebbles or stones occur in it, the few that I have found being subangular with some faces polished and others rough. Under the microscope it appears to be a fine "rock flour" containing a few minute angular fragments of quartz, orthoclase, microcline, etc., as well as many indeterminable particles.

Towards the top this clay merges into an unstratified brownish clay with many boulders of Silurian and Laurentian origin, some fairly well rounded, others subangular and more or less striated. The line between the brown clay and the overlying sandy soil also is not well marked. In the soil and on the surface are many large Archæan boulders, one mass of gneiss measuring nearly six feet in longest diameter. The top of the section, 140 feet above the Don, is at the level of the plain on which the northern part of Toronto is built, a plain extending several miles to the westward, but cut off a quarter of a mile to the north by the Davenport ridge. Several other exposures along the Don and its tributaries or at railway cuttings in the neighborhood show similar sections of stratified sands and clays, but, as far as observed, without fossils. The upper boulder deposit is better displayed at the end of the C. P. R. trestle, a quarter of a mile to the south, than at the quarry itself. Here ten or fifteen feet of sandy clay containing boulders, especially of limestone, beautifully polished and striated on some faces, form the uppermost layer, and rest upon the same thick bed of finely stratified bluish-gray clay observed at the quarry.

The Davenport ridge, really a plateau rising 30 or 40 feet above the plain to the south, is found, where laid open by cuttings for roads or railways, to consist in its upper part of unstratified sand with numerous pebbles and boulders distinctly polished and scored, the whole evidently a glacial deposit of somewhat different materials from those of the till at the bottom of the series. These glacial sands once extended much farther to the south than now, perhaps reaching the present lake shore, but wave action has washed them away, leaving behind the large boulders once so thickly scattered over the site of Toronto, though now mostly removed for road-making purposes.*

Comparing the section just given with one kindly furnished by Dr. Brodie from a locality now buried from view, at the Winchester street bridge, there are below the level of the lake, resting on Hudson River shale, six feet of uncertain materials, five feet of a deposit containing leaves, wood and Cyclas goniobasis (?), and five feet of till with boulders differing from those found higher up. The upper part of this bed rises a little above the level of the lake. Upon this follow first a lacustrine deposit, say fifteen feet, with wood, leaves, Cyclas and Unios; next, glacial clay with very large boulders of gneiss, etc.; and finally lake shore sand, not continuous.

A somewhat different account of the section is given by Mr. Townsend, as quoted by Sir Wm. Dawson.† Reversing the order in which Mr. Townsend arranges the series, we find blue till resting on the Hudson River beds; then sixteen feet of alternating sand and dark-colored clay with freshwater shells and wood; three feet of ferruginous sand with argillaceous nodules (one containing a maple leaf); twenty-four feet of tough, stratified blue "Erie clay;" and finally twenty-six feet of fine, light-colored sand, with layers of clay at bottom.

The lowest fossiliferous deposit, mentioned by Dr. Brodie but not by Mr. Townsend, is perhaps preglacial. The fifteen or sixteen feet of lacustrine deposit just above the till, correspond to the Unio- and Pleurocera-bearing beds of the brickyard.

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*Glacial Phenomena of Canada, etc., Prof. Ramsey, Can. Nat. and Geol., 1859, pp. 328. He gives a section of Toronto drift, showing boulders.

†Bull. Geol. Soc. Am., vol. I, p. 315.

The section measured by Mr. G. J. Hinde at Scarboro' Hights differs more widely from the one described in the present paper, since there the lowest boulder clay is separated from the second by 140 feet of fossiliferous clay and sand.* It is clear that our drift deposits vary greatly within comparatively short distances.

In interpreting the facts observed in the Don valley we have a first Ice age in which the glacier worked up the Hudson River shales into boulder clay, kneading in a few Archæan boulders, and spreading a tough carpet of till in a gentle slope toward the hollow of lake Ontario, and then withdrew; followed by the waters of the lake, which stood 40 or 50 feet above its present level, if we suppose no change in the hight of land above sea at this point. Mr. Simpson supposes that the lake was ice-dammed at this stage,† and drained into the Mississippi, making it possible for mollusks belonging to the Mississippi fauna to invade waters normally flowing into the St. Lawrence. The supposition is a natural one, but seems contradicted by the fact that at present the watershed between lake Ontario and the tributaries of the Mississippi is several hundred feet above the level of the lake. I have seen no reports of buried channels going low enough to drain lake Ontario into the Mississippi down to a level only 50 feet above the present, though of course, the possibility of finding one cannot be denied. There seems more evidence of an old channel leading past Syracuse through the Mohawk valley into the Hudson,‡ which would not account for the presence of Mississippi forms in Ontario, however. In whatever way they were introduced, there is no doubt that during interglacial time eight or ten species of Unio, several no longer found in our waters, lived at the mouth of the Don, first on the scarcely disturbed surface of the till, afterwards on beds of sand and well rolled gravel brought down by the river and spread in its shallow estuary. On the banks of the prehistoric Don grew trees such as now flourish in the same region, yews and cedars, maples, oaks and ashes; as well as the papaw, now, I believe, not occurring north of the lake. Judging by the flora and fauna the climate was by no means subarctic, but on the contrary fully as mild as at present, if not a little milder.

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*Jour. Can. Inst., vol. xv, p. 392.

†Proc. Nat. Museum, No. 952, p. 593.

‡Wright, Man and the Glacial Period, p. 202.

The length of the interglacial time was sufficient for the deposit of 24 feet or more of sand and clay on the Don and 140 feet of similar materials at Scarboro' Hights, and for the growth of large forest trees.

It is generally supposed, from the direction of glacial striations and of the transport of boulders, that the center from which the ice radiated was at the watershed between the St. Lawrence and Hudson bay or somewhat farther east in Labrador, at the farthest not more than 700 miles from Toronto. At the present time in southern British Columbia névé is scarcely found on mountains rising less than 8,000 feet above sea level, and glaciers hardly come down to 5,000 feet. It is probable that a depression of the highest points to 7,000 or 8,000 feet would completely wipe out all the glaciers of southern British Columbia. So far as I am aware, no point reaches 3,000 feet above sea level between Ontario and Hudson bay, and no point in Labrador rises much above 6,000 feet. Unless the northern watershed stood very much higher above lake Ontario than at present, it is impossible to imagine a wide spread sheet of ice existing there during interglacial time, when oaks and maples and papaws flourished on the land and Mississippi Unios in the waters only 400 or 500 miles to the southeast. I know of no evidence proving that the glacial center stood at that time 3,000 or 4,000 feet higher above lake Ontario than at present, and hence conclude that the ice fields were completely melted during the interglacial epoch, instead of merely receding a comparatively short distance before advancing again.

After the deposit of the fossiliferous beds the lake rose to at least 140 feet above its present level, perhaps dammed at its eastern end by the return of the ice during the second glacial period, and thick beds of clay were laid down in quiet water. Probably the Don at this time was a glacial stream, bringing down rock flour from the not far distant ice front, as the upper waters of the Athabasca now do, and depositing it on the floor of a lake too muddy and cold for life.

A further advance of the glacier buried the stratified clay beneath 30 or 40 feet of sandy clay and sand containing numberless subangular, striated stones and some boulders of Laurentian and Silurian rock several tons in weight. These materials show little or no stratification and are not waterworn so far as I have observed. The striæ on limestone pebbles are sharp, and there are flat pebbles of soft Utica shale here 20 miles from home, which would have been destroyed if transported by wave action or by running water. The clays under this second glacial deposit appear to have been very little disturbed by the passage over them of the glacier.

When the ice of the second glacial epoch retreated, the lakes, whether dammed by an eastern tongue of ice or lowered to the level of the sea, formed a beach now 140 feet or more above the lake, Spencer's Iroquois beach.* Wave action removed the loose materials as far as the Davenport ridge, which forms so prominent a feature of the northern part of the city, the heavier stones being left where they rested as a boulder pavement. At the Iroquois stage the lake is considered to have drained into the Hudson. Several of the Unios exterminated by the second advance of the ice did not return when the ice retreated again. Was the continuously icy water unfavorable to the species which failed to return? Mr. Simpson supposes that some change in the drainage system prevented them from regaining the lost ground.† The change from the Iroquois level to the present one must have been rapid, leaving no time for the formation of intermediate beaches. Since the change of level the Don and its tributaries have had time to remove the drift deposits down to base line for more than a mile north of Toronto bay.

NOTE ON INTERGLACIAL PLANTS FROM THE DON VALLEY.

By Prof. D. P. PENHALLOW, McGill University, Montreal.

From time to time there have been brought to light a number of interesting plants from the interglacial formation of the Don valley near Toronto. These, chiefly in the form of lignite, have thrown much light upon the vegetation of that time, and show that in the arborescent forms at least, the species were such as may now be found in the same region. On the 7th of November, 1893, Prof. A. P. Coleman, of Toronto, sent me three excellent specimens of interglacial lignite for determination. They represented fragments of branches which must have been several inches in diameter when growing. Outwardly the material appeared well preserved, and after boiling in carbonate of potash for about two hours was found to be sufficiently soft and free from siliceous matter to section freely. It was therefore imbedded in paraffine and sectioned on a microtome.

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*Deformation of Iroquois Beach and Birth of Lake Ontario, Am. Jour. Sci., Vol. XL, Dec., 1890, p. 446.

†Proc. Nat. Museum, Vol. XVI, p. 595.

Upon examination of the sections it was found that the structure had been greatly altered by decay and compression, so that, with the exception of number two, reference to species could not be made with certainty.

As, however, previous experience has shown the close identity between the interglacial vegetation and that of our own time in the same locality, it is probably admissible to refer doubtful species to those modern species which they most nearly approach, and it may be that future material, more perfectly preserved, will enable us to decide more definitely as to the specific value of such provisional reference. There is, at any rate, the great advantage of avoiding the introduction of new names which may hereafter require to be abolished.

No. 1. FRAXINUS QUADRANGULATA Michx.

The specimen marked No. 1, was much altered by compression and decay, so that the transverse section was much disturbed, while the longitudinal sections exhibited but poorly a very few of the characters upon which specific distinction is to be based. From the former, however, it was at once clear that the plant was a Fraximus, and as, of existing species, it seems to approach most nearly to *F. quadrangulata*, I consider it proper to refer it, provisionally, to that species. So far as I am aware this is the first record we have of this genus in the interglacial of Canada. Fraxinus quadrangulata is at present found in Canada along the shores of lake Erie, and particularly about point Peter. (*Macoun.*)

No. 2. TAXUS BACCATA L., var. CANADENSIS Gray.

Specimen No. 2 showed the characteristic structure in cross section very clearly. In longitudinal section the usual markings of the tracheid walls were found to be largely obliterated, even to the bordered pits, but enough evidence remained to enable me to refer the specimen without doubt to *Taxus baccata* L., var. *canadensis* Gray.

This species has hitherto proved a somewhat common one in the interglacial of Canada, particularly in the Don valley.*

No. 3. QUERCUS OBTUSILOBA Michx.

Specimen No. 3 showed considerable alteration. While in transverse section the quercic characters are well defined, in longitudinal sections the structural markings were almost obliterated. The resemblance of this wood to modern oaks was found to be most marked in the case of *Quercus obtusiloba* Michx., to which I therefore refer it, provisionally. This is the first time an oak has been found in the interglacial of Canada.

Quercus obtusiloba is now found in southern Ontario, and particularly about the bay of Quinte (*Macoun*).

ON THE VALUE OF SUPPOSED ALGÆ AS GEOLOGICAL GUIDES.

By JOSEPH F. JAMES, M. Sc., F. G. S. A., etc.

[Read before Am. Asso. Adv. Science, August, 1893.]

In the discussion of the evolution of the vegetable kingdom it has been the habit to refer to the Algæ as appearing very early in time, and as furnishing one proof of the theory of derivation and descent from the simple to the complex. In the pursuance of this one writer† has given the number of the species of Algæ that have been found in various strata, and has constructed a chart showing their gradual increase from early to recent times. Other writers have placed groups of rocks in the same time epochs upon the presence of certain of these organisms, while still others have gone so far as to make new genera for fossils because they occurred in a different locality, and were of a different geological age, and because they did not believe that Algæ could persist through the requisite time interval. The new genera are made, notwithstanding they resemble each other so much that, were they found in the same beds, or even in the same horizon, they would undoubtedly have been placed in the same genus.

It has now come to be well recognized that Algæ existed at a very early period in the history of the earth. The abundance of graphite in the Laurentian rocks has caused many authors, Sir William Dawson among others,* to postulate the existence of cellular organisms, certainly aquatic and possibly terrestrial, during the long pre-Cambrian epochs. In regard to the possible existence of these forms of life, he says:

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*The Pleistocene Flora of Canada, Bull. Geol. Soc. Am., I, 321.

†Ward, L. F. Sketch of Palæobotany. Fifth Ann. Rept., U. S. Geol. Sur., 1885.

> "The climate and atmosphere of the Laurentian may have been well adapted for the sustenance of vegetable life. We can scarcely doubt that the internal heat of the earth still warmed the waters of the sea, and these warm waters must have diffused great quantities of mists and vapors over the land, giving a moist and equable, if not very clear, atmosphere. The vast quantities of carbon dioxide, afterwards sealed up in limestones and carbonaceous beds, must also have still floated in the atmosphere, and must have supplied abundance of the carbon, which constitutes the largest ingredient in vegetable tissues. Under these circumstances the whole world would have resembled a damp, warm greenhouse, and plants loving such an atmosphere could have grown luxuriantly. In these circumstances the lower forms of aquatic vegetation and those that love damp, warm air and wet soil would have been at home. * * The Algæ may have attained to gigantic dimensions, and may have even ascended out of the water in some of their forms. * * Comparatively simple cellular and tubular structures, now degraded to the humble position of flat lichens or soft or corky fungi, or slender cellular mosses, may have been so strengthened and modified as to constitute forest trees." (pp. 17-18.)

We have still further presumptive evidence of the existence of aquatic vegetation in early Cambrian and Paleozoic times in the presence of vast numbers of animal forms which we are justified in believing subsisted upon such vegetation. But while we may inferentially postulate the existence of Algæ, it seems more than likely that the greater majority of the fossils described as Algæ are not such at all. This matter has been so often referred to, however, that it need not be discussed here. It is the intention to call attention to certain facts which have been noted by many observers in respect to the positions where the supposed Algæ occur, and to discuss their value as geological guides.

The fossils are nearly always found as elevations upon the lower surfaces of the rock, although it sometimes happens that they are upon the upper surface. It has also been frequently remarked that where they occur, other and undoubted organic forms are absent. This is stated in the description of nearly every species and has been repeatedly noticed by myself in various localities. They are nearly always accompanied by raindrop impressions, undoubted worm tracks, or schematic markings. The absence of other organic forms is almost in itself sufficient to stamp them as of inorganic origin. They occur in vast profusion, filling whole surfaces of rock through many vertical feet of strata, and many attain a great size and length, ten or fifteen feet being not unusual.

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*Geological History of Plants. New York, 1888, pp. 12-19.

The data upon which any chart or any scheme showing derivation is based is necessarily derived from the published descriptions of species and genera. The more numerous these are the larger the amount of data upon which conclusions are based. But when a critical examination shows that there are more genera and species made than there is reason for, when it is shown that the increase of genera and species is due to the fact that new forms are made for no other reason than that they are found in different horizons, the value of the data depreciates very materially. When still further study shows that the species and genera charged to Algæ are not really such, the value of the deductions fades away entirely. Such we believe to be the case; so that, much as we may believe in the evolutionary theory, we do not believe it receives support from such deductions. This conclusion was also reached by Williamson in 1885 as shown in a paper read in that year.* In discussing problematic organisms after referring to the diversity of opinion as to their true nature, he says that the objects "can have no weight with the student of evolution, and until we obtain more definite proofs than we have heretofore obtained of the vegetable nature of most of these dubious 'Paleozoic Algæ,' we must reject their testimony when framing a pedigree for the vegetable kingdom. At the same time I regard the existence of an abundant marine vegetation during the Paleozoic ages as an inevitable corollary of the fact that the rocks of those ages abound in the remains of phytophagous animals." (p. 28.)

The correlation of the strata of one country, or part of one country, with another, has also been frequently made upon the presence of one or more of these organisms. Deductions, for example, have been made upon *Scolithus linearis*, the presence of this fossil having caused Billings* to place strata on the Strait of Belle Isle, now recognized as Lower Cambrian, in the same horizon as the Potsdam of New York, now in the Upper Cambrian. So the Chilhowee of Tennessee has been placed in the Potsdam upon the evidence of the same fossil, whereas it is really Lower Cambrian.† H. M. Ami, in 1887‡ when discussing the occurrence of *Scolithus canadensis* in the Chazy of Canada said "that the occurrence of *Scolithus* remains does not necessarily indicate the presence of Potsdam rocks, but that the beds may possibly be newer or higher up in the series." The same fact was mentioned by Brainerd and Seely§ when discussing the rocks of the Champlain lake region. They stated that "the fucoids, so far as we have seen, are not characteristic of any one division, though they appear abundantly in various horizons of D. Further, *Scolithus* can not be regarded as indicating a Potsdam horizon, as the most abundant display we have ever seen is to be found at the bottom of Division C, 600 or 700 feet above the Potsdam sandstone." Professor Lesley quotes this statement and agrees with it.‖ But he had come to the same conclusion fifteen years before. In a discussion of fucoids in that year,** he called attention to their wide time range and said:

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*Williamson, W. C. On some undescribed tracks of invertebrate animals from the Yoredale rocks, and on some inorganic phenomena produced on tidal shores, simulating plant remains. Mem. Manchester Lit. and Phil. Soc., 3d ser., vol. x, pp. 19-29.

"There may have been different species, but certainly most of the marine Algæ had a large vertical time-range through the Palæozoic formations.

"Consequently they can not be used as geological guides. We know nothing about their internal structure. They were cellular masses, easily rotted, rapidly losing shape when dead, and leaving on the ancient shore-sand mere molds or indistinct impressions. They cover, by millions, the Chemung rocks (Oil system), and have a thousand shapes which seem at first to be easily classified into species and genera; but the task is fruitless; form graduates into form, and no specific marks

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*Billings, E. Palæozoic Fossils, 1861, p. 2.

†Walcott, C. D.

‡On the occurrence of *Scolithus* in rocks of the Chazy formation about Ottawa, Canada. Canad. Rec. Sci., vol. II, p. 304.

§Bull. Geol. Soc. Am., vol. I, 1890, pp. 501-511.

‖Dictionary of Fossils of Penn. P4, vol. III, p. 943.

**On a map and profile of Coal and Oil Measures along Slippery creek in Lawrence county, Pennsylvania; from a Survey in 1864 by J. P. Lesley and Leo Lesquereux. 2d Geol. Sur. Penn., J, 1875, pp. 90-107.

> can be detected. Whole fields of this ancient marine vegetation appear like a grass plot, each blade of which has some peculiar feature, but none marked enough to make it positively distinct. Either there are as many species as individuals, or all belong to one species, represented by a great number of closely allied varieties. They can not be used as geological guides." (pp. 100-101.)

Count H. Solms-Laubach* uses equally strong language when discussing Algæ. Besides the genuine Algæ, he says:

> "There still remain a large number of forms from all the formations, from the Quaternary back to the Lower Silurian, which have been described under an abundance of generic names; but they have virtually no interest to the botanist, because there is no immediate possibility of profitable comparison with known algal types. We may, perhaps, be able at some future time to pick out a type here and there [from] this hopeless chaos, but it is scarcely possible that we shall ever attain to a better position as regards the remainder. We must necessarily be always dependent on characters derived from external form, and these in the case of the Algæ prove only too little; we can scarcely hope to penetrate to the inner structure of the fructification, which can alone determine the affinity. And, to meet an objection which may be expected from the paleontologists, I will add at once that I should not hesitate to say the same of the Coniferæ, for instance, if we had nothing left of them but the impressions of the leaves; but there we are better off, for cones, wood and fragments showing anatomical structure have been preserved as so many points of support for the conclusions, by which we can be continually testing the degree of probability to be assigned to the new conquests. What mistakes may be made without the aid of such objects is shown by the number of impressions of conifers, which are explained by older authors, by Brongniart for example, as *Zonarites digitatus*, various Caulerpitæ, and other Algæ."

The illustrious algologist, Harvey, gives similar testimony. Rogers, in the Geology of Pennsylvania,† refers to certain fossil remains found by him and supposed to be plants. They were sent to Prof. Balfour who wrote as follows in regard to one which presents many points of resemblance to the genus *Dendrophycus*, and which, notwithstanding the opinions of Newberry and others, I for one can not but regard as the imprint of drainage channels upon mud. Prof. Balfour says:

> "On the whole subject of such fossil forms, I would take leave to forward to you the following words of Harvey, who in speaking of the seaweed called *Ptilota rhodocallis* says: 'At first sight this beautiful species might almost be taken for *Rhacelocarpus billardieri*, so similar are its ramifications and color; but the structure of the frond and the

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*Fossil Botany. Translated by Garnsey and Balfour. London, 1891, p. 45 et seq.

†Vol. II, 1858, pp. 830 and 884.

fructification are so different that we are forced to refer these Algæ to widely separated families. Geologists sometimes complain that botanists refuse definitely to name fossil plants whose impressions are left in sandstone, and, in the geological sense, *well preserved*; but cases such as the present—and it is one out of a thousand—show how uncertain must be the *determination* even of the best stone printing of a fossil stem. What shall we say, then, of the positive settlement of the affinities and structure of fossil shadows, where there does not remain the faintest trace in stone of the entity that was and is not?'"

Brongniart also refers* to the great time range of certain species described as Algæ under the name of *Chondrites.* They occur in vast numbers in the Flysch of Switzerland, the species passing by insensible gradations into each other. After giving a list of twelve species of the Algæ, Brongniart says:

"The remarkable points about this series of species are, that they have nothing in common either with the Algæ of the sub-Cretaceous epoch, nor with those of the Miocene: especially of Monte Bolca, with which this flora would be almost contemporaneous, according to many geologists; and again, the identity of these species of Algæ in so many localities situated at great distances, localities so numerous for most of these species that I have not been able to cite them. M. Kurr has also described and figured under the name of *Ch. bollensis*, a Fucus of the Lias, the very varied forms of which are almost identical with *Ch. targionii*, *æqualis* and *difformis*," all of which are given in the list referred to.

The type of so-called seaweeds variously known under the names of *Spirophyton*, *Taonurus*, *Alectorurus*, *Zoophycos*, *Physophycus* and *Cancellophycus* presents an instance of the excessive multiplication of genera for the simple reason that they occur at different geological horizons. For example, *Alectorurus* is supposed to characterize the Silurian; *Physophycus* the Carboniferous; *Spirophyton* the Devonian; *Cancellophycus* the Jurassic; *Zoophycos* and *Taonurus* the Cretaceous or Eocene. Saporta when proposing the generic name *Cancellophycus* said:†

"We replace by a new generic name those species of *Zoophycos* and *Taonurus*, applied, the one by Massalongo and Heer, and the other by Fischer-Ooster, to those Algæ represented by the type of *Chondrites scoparius* of Thiolliere. Not only do these terms appear to us improper, but in the opinion of the authors who have proposed them, they designate especially species of the Flysch, the identity of structure of which with the Jurassic forms that we here describe is far from being proved; this identity, at all events, is doubtful, on account of the distance that separates the two epochs, a fact the more curious that it has been wished to be verified. Many types of Algæ, anterior to the species composing the group of *Chondrites scoparius* show among themselves analogies very close to *Taonurus* of the Flysch; every one of them is, however, distinguished by a particular generic name. The resemblance of these successive forms, constructed more or less upon the same plan, compels us to admit the existence of a great family, now entirely extinct, that from Palæozoic time to the Miocene, has not ceased to have some representative in the seas of our hemisphere."

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*Chronological exposition of the periods of vegetation and the different floras which have successively occupied the surface of the earth. Ann. and Mag. Nat. Hist., 2d ser., vol. VI, London, 1850, p. 353. Trans. by Arthur Henfrey from Ann. d. Sci. Nat. Botan., ser. 8, vol. XI, May and June, 1849.

†Plantes Jurassiques. Pal. Francaise, 2d ser. Veg. Text, p. 127.

The contrast between these remarks by an author who would have a new genus for each successive geological horizon and a new species on almost every turn of the fossil form, with those of Lesquereux, who was also quite prone to make new species, is striking. In respect to the genus *Taonurus* he says:*

"All the forms of *Taonurus*, considered as specifically different, may perhaps be modifications or varieties of one. They are rarely found in a good state of preservation and are difficult to study."

The erroneous deductions which have been made upon the remains of pseudo-algæ, as they are here considered, might be greatly multiplied. It is not, however, necessary to do this now. The following conclusions, we believe, may be fairly drawn from what has been given above:

(1) The presumptive evidence of the presence of Algæ in early geological time is good, but there is not good evidence that the greater number of species described as Algæ are really such; and any deductions based upon the number of genera and species recorded by authors are defective. (2) The great similarity of forms like *Scolithus* having a very great time range, is against their use as geological guides. (3) The poor state of preservation and the great variability they present is also an argument unfavorable to their use. (4) Unless the deductions made are corroborated by other evidence than that afforded by presumed fossil Algæ, they can not be considered as having any great value. This other evidence must come from the presence of undoubted organized forms, or from stratigraphical evidence which can not be gainsaid.

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*Coal Flora. 2d Geol. Sur. Penn., P, vol. I, 1880, p. 9.

A REVISED CLASSIFICATION OF THE SPIRE-BEARING BRACHIOPODA.

By CHARLES SCHUCHERT, Washington, D. C.

In the March number of the AMERICAN GEOLOGIST for 1893, the writer published a paper entitled "A Classification of the Brachiopoda." Several works on the spire-bearing brachiopods have since appeared,* which greatly increase the knowledge of the suborder *Helicopegmata*, and suggest a more natural classification than was then possible. Therefore the following revised classification is offered:

Family Characters. Three types of brachidial structure of family importance have been observed which will serve to characterize the three families into which the suborder *Helicopegmata* is here divided. These structures are based on the position of the primary lamellæ with reference to the spirals and to the manner in which they join with the crura. These characters are as follows:

1. In the earliest and most primitive forms, the *Atrypidæ*, the primary lamellæ are directly continuous with the crura, diverge widely and have the spirals between them.

2. In the *Spiriferidæ*, the primary lamellæ are also directly continuous with the crura, but lie between the spirals, thus being the reverse of the *Atrypidæ*.

3. In the *Athyridæ* the primary lamellæ differ in direction from those in the other families in being more or less sharply recurved dorsally near their junction with the crura.

Subfamily characters. The nature and complexity of the loop which joins the spirals is the most important character for subfamily differentiation. There are five types of loops, the greatest variety occurring in the *Athyridæ*. Two of these are restricted, being common to the *Atrypidæ* and *Spiriferidæ*, while the three pertaining to the *Athyridæ* are specializations of the primitive loop of the two other families. These types may be defined as follows:

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* James Hall, assisted by John M. Clarke. An Introduction to the Study of the Genera of the Palæozoic Brachiopoda, Pal. New York, vol. viii, pt. ii, fascicle i, pp. 1-176, July, 1893.

A. Bittner. Brachiopoden der Alpinen Trias, Abh. d. k. k. geol. Reichs., Bd. xiv, pp. 1-325, Taf. 1-41, 1890; Nachtrag I, Ibid., Bd. xvii, Heft 2, pp. 1-40, Taf. 1-4, 1892; Neue Koninckiniden des Alpinen Lias, Jahrb. d. k. k. geol. Reichs., Bd. 43, Heft 1, pp. 133-144, Taf. iv, 1893.

C. E. Beecher and C. Schuchert. Development of the brachial supports in Dielasma and Zygospira, Proc. Biol. Soc. Washington, vol. viii, pp. 71-82, 1893.

1. Primitive loop a simple band, variously situated, becoming in the higher forms more or less V-shaped. Present in *Zygospirinæ*, *Dayinæ*, *Suessiinæ*, and *Uncitinæ*.

2. Loop a simple band in young or immature stages, but at maturity more or less medially absorbed, and eventually only represented by two short prongs, one attached to each primary lamella. Characteristic of *Atrypinæ* and *Trigonotretinæ*.

3. Loop V-shaped, with its apex more or less drawn out into a simple or terminally modified extension, which is but rarely bifurcated. Present in *Anoplothecinæ*, *Rhynchospirinæ* and *Hindellinæ*.

4. The loop process always present with the distal end bifurcated. The branches are of variable lengths and either terminate freely between the first and second volutions of the spirals, or may continue with these to their outer ends. Present in *Athyrinæ*, *Diplospirinæ*, and *Koninckininæ*.

5. The branches of the process remain between the spirals, recurve and join near their origin, thus resembling the handles of a pair of scissors. Present in *Meristellinæ*.

The ontogeny of *Zygospira* indicates that the *Helicopegmata* was the last to appear and had its origin in the *Ancylobrachia* or terebratuloids. The suborder first manifests itself as far as known in the lower portion of the Lower Silurian. It attains its climax of differentiation in the Devonian, with another outburst of specialization in the Triassic chiefly among the double-spired athyroids, while there is rapid decline and final extinction in the Jurassic. Of the eight suborders into which the class Brachiopoda is now divided, only one, the *Trullacea*, or pentameroids, became extinct before the *Helicopegmata*. These two suborders are the only extinct ones of the class. The other six groups still have living representatives, are widely distributed, and are represented by about one hundred and thirty species.

Suborder **HELICOPEGMATA**, Waagen 1883.

Spiriferacea, Waagen 1883.

Brachiopods in which the two spirally enrolled brachia have internal calcified supports which are more or less completely joined by a simple or variously modified and complicated calcareous loop.

I. Family **ATRYPIDÆ,** Dall 1887.

Crura directly continuous with the primary lamellæ which diverge widely and have the spirals between them. Loop simple, complete or incomplete; shell structure impunctate.

A. Subfamily Zygospirinæ, Waagen 1883.

Anazygidæ, Davidson 1884.

Loop a single connecting band either posteriorly or anteriorly directed. Spirals usually introverted, with their apices toward the median dorsal region.

- Zygospira, Hall 1862.
  - Stenocisma, Hall 1874 (not Conrad 1839; Hall 1867).
  - Anazyga, Davidson 1882.
  - Orthonomæa, Hall 1858.
  - Hallina, Winchell and Schuchert 1892.
  - Protozyga, Hall and Clarke 1893.
- Catazyga, H. and C. 1893.
- Atrypinæ, H. and C. 1893.
- Glassia, Davidson, 1882.
- ? Clintonella, H. and C. 1893.

B. Subfamily Dayinæ, Waagen 1883.

Loop drawn out posteriorly into a simple short process. Spirals laterally directed.

Dayia, Davidson 1882.

A^1. Subfamily Atrypinæ, Waagen 1883.

Loop situated extremely posterior, complete in young stages, but at maturity medially absorbed. Spirals dorsomedially directed.

- Atrypa, Dalman 1828.
  - Cleiothyris, Phillips 1841 (not King 1830).
  - Spirigerina, d'Orbigny 1847.
- Grünewaldtia, Tschernyschew 1885.
- ? Karpinskya, Tsch. 1885.

II. Family **SPIRIFERIDÆ,** King 1846 (emend Davidson).

Martiniinæ and Reticulariinæ, Waagen 1883; Spiriferinidæ, Davidson 1884.

Primary lamellæ directly continuous with the crura and situated between the laterally directed spirals, except in *Cyclospira* where they are somewhat introverted. Loop simple, complete or incomplete.

A. Subfamily SUESSIINÆ, Waagen 1883.

Loop a continuous, more or less V-shaped band.

- Cyrtina, Davidson 1858.
- Thecocyrtella, Bittner 1892.
    - Cyrtotheca, Bittner 1890 (not Salter).
- Spiriferina, d'Orbigny 1847.
- Suessia, Deslongchamps 1854.

Subfamily UNCITINÆ, Waagen 1883.

Loop as in *Suessiinæ*. Just within the posterior margin of the dorsal valve are pouch-like plates. Deltidial plates united, deeply concave. Subfamily anomalous.

- Uncites, Defrance 1825.
- ? Uncinella, Waagen 1883.

B. Subfamily TRIGONOTRETINÆ, Schuchert 1893.

Delthyrinæ (part), Waagen 1883.

Loop at maturity largely absorbed medially, being then represented by two processes, one attached to each primary lamella.

- ? Cyclospira, Hall and Clarke 1893.
- Spirifer, Sowerby 1815.
    - Choristites, Fischer, de Wald. 1815.
    - Trigonotreta, Koenig 1825; Meek and Hayden 1864.
    - Spiriferus, Blainville 1827.
    - Spirifera, J. de C. Sowerby 1835.
    - Brachythyris, McCoy 1844.
    - Fusella, McCoy 1844.
    - Hysterolithus, Quenstedt 1871.
- Cyrtia, Dalman 1828.
- Syringothyris, Winchell 1863.
    - Spirifer, Meek and Hayden 1864.
- Delthyris, Dalman 1828.
- Martinia, Waagen 1883.
- Martiniopsis, Waagen 1883.
- Mentzelia, Quenstedt 1871.
- Ambocœlia, Hall 1860.
- Reticularia, McCoy 1844.
- Verneuilia, H. and C. 1893.
- ? Metaplasia, H. and C. 1893.

III. Family **ATHYRIDÆ**, Phillips 1841.

Nucleospiridæ, Davidson 1882; Koninckinidæ, Davidson 1853.

Primary lamellæ situated between the spirals, and sharply recurved dorsally at their junction with the crura. Spirals more or less laterally directed. Loop complete, V-shaped, the apex being always drawn out into a simple, bifurcated, or otherwise terminally modified, process.

A. Subfamily RHYNCHOSPIRINÆ,* n. subfam.

Retziinæ, Waagen 1883.

The single process of the loop commonly sharply recurved, but sometimes bifurcated. Shells plicate; structure distinctly punctate.

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*Since Retzia does not express the characters of this subfamily as well as Rhynchospira does, Waagen's term Retziinæ is here abandoned.

Homœospira, Hall and Clarke 1893.
Rhynchospira, Hall 1859.
Ptychospira, H. and C. 1893.
Eumetria, Hall 1864.
Trematospira, Hall 1857.
Parazyga, H. and C. 1893.
Acambona, White 1862.
Hustedia, H. and C. 1893.
Retzia, King 1850.
    Trigeria, Bayle 1878.

B. Subfamily HINDELLINÆ, n. subfam.

Loop with a single process which may be simple, or may articulate in a ventral septal socket, sometimes (rarely) being sharply recurved terminally. Shells smooth, finely spinose, or plicate; structure impunctate.

Hindella, Davidson 1882.
Whitfieldella, H. and C. 1893.
    Meristina, Davidson 1882 (not Hall 1867).
Nucleospira, Hall 1858.
Hyattella, H. and C. 1893.
Anoplotheca, Sandberger 1856.
    Bifida, Davidson 1882.
    Cœlospira, Hall 1863.
    Leptocœlia, Hall 1857 and 1859
Vitulina, Hall 1860.
? Anabaia, Clarke 1893.

B¹. Subfamily ATHYRINÆ, Waagen 1883.

The single process of the loop with distal bifurcations which may or may not terminate between the first and second volutions of the spirals. Shells smooth, lamellose spinose, or with a few sharp, non-alternating plications; structure impunctate.

Meristina, Hall 1867.
    Athyris, Davidson 1853 (not McCoy 1844).
    Whitfieldia, Davidson 1882.
Glassina, Hall and Clarke 1893.
Athyris, McCoy 1844.
    Spirigera, d'Orbigny 1847.
    Euthyris, Quenstedt 1871.
Actinoconchus, McCoy 1844.
Cleiothyris, King 1850 (not Phillips, 1841).
Seminula, McCoy 1841.
Spirigerella, Waagen 1883.
Anomactinella, Bittner 1890.
Pomatospirella, Bittner 1892.
Amphitomella, Bittner 1890.
Plicigera, Bittner 1890.
Tetractinella, Bittner 1890.
Pentactinella, Bittner 1890.

B². Subfamily DIPLOSPIRINÆ, n. subfam.

Bifurcations of the loop process very long, lying between the volutions of the spirals, and continuing with these to their outer ends. Sometimes there is an additional process on the apex which articulates with the ventral valve. Shells smooth or plicate; structure impunctate.

Kayseria, Davidson 1882.
Diplospirella, Bittner 1890.
Euractinella, Bittner 1890.
Pexidella, Bittner 1890.
Anisactinella, Bittner 1890.

C. Subfamily KONINCKININÆ, Waagen 1883.

Amphiclininæ, Waagen 1883; Diplospidæ and Diplospiridæ, Munier-Chalmas, 1880.

Loop and spirals essentially as in *Diplospirinæ*. The spirals in *Koninckininæ*, however, are not laterally directed as in the former group, but point ventrally, which is due to the strophomenoid form of the shell. Cardinal areas more or less well developed. Shells smooth; structure impunctate.

Koninckina, Suess 1853.
Amphiclina, Laube 1865.
Koninckella, M.-Chalmas 1880.
Koninckodonta, Bittner 1893.
? Thecospira, Zugmeyer 1880.
? Amphiclinodonta, Bittner 1890.

B^a. Subfamily MERISTELLINÆ, Waagen 1883.

The loop bifurcations do not enter the spirals, but recurve and join near their origin. Shells smooth; structure impunctate.

Meristella, Hall 1860.
Charionella, Billings 1861.
? Pentagonia, Cozzens 1846.
  Goniocœlia, Hall 1861.
Dicamara, Hall and Clarke 1893.
Merista, Suess 1851.
  Camarium, Hall 1859.
Dioristella, Bittner 1890.
? Camarospira, H. and C. 1893.

U. S. National Museum, December, 1893.

PHOSPHATE-BEARING ROCKS IN MIDDLE TENNESSEE.—PRELIMINARY NOTICE.

By J. M. SAFFORD, State Geologist, Nashville.

Within the highland belt of country lying west of the meridian of Nashville, and between that and the Tennessee river, the phosphate-bearing beds associated with the Black Devonian shale are just now attracting attention on account of the prospect of finding certain parts of them rich enough in phosphate material to be of economic importance. There are two beds or strata containing such material, one immediately above the Black shale and the other immediately below it.

That above the shale is a bed made up more or less of grayish, rounded, concretionary masses, named, in the writer's notes, "balls" and "kidneys." These have been long known to be quite rich in phosphate, and search has been made for the localities where they occur most abundantly. Some of the masses yield from 50 to 65 per cent. of phosphate ($Ca_3 2PO_4$), the other constituents being calcium carbonate, the oxides of alumina and iron, silica and organic matter. When broken the interior often has a granular, open structure, and now and then exhibits fossils, chiefly individuals of a species of Lingula. When struck with a hammer they give off a fetid odor.

The bed below the shale has been less studied. Its weathered outcrop has the appearance of a yellowish sandstone and may often be seen on the slopes of many valleys in the great highland region southwest from Nashville. Of late it has been found to yield locally a very promising percentage of phosphate, and investigations are now going on looking to its full development. The analyses so far made indicate the presence, in some samples, of as much as 50 to 70 per cent., or more, of phosphate. The more complete results will be given hereafter. At certain points the bed contains fish teeth and fragments of bone, having the appearance of a bone bed. It also shows occasionally indications of a coprolitic origin.

The generalized section below, in descending order, made from many observations taken in Maury and Lewis counties, will serve to illustrate the relation of the two phosphate-bearing beds to the Black shale and other associated formations.

Section in Maury and Lewis counties, Tenn.

1. *Harpeth shale;* light blue shale; base of Sub-carboniferous or Mississippian.

2. *Bed of concretionary masses,* of spherical, kidney- and cake-shaped forms, containing phosphate. These vary in size from that of pigeons' eggs to forms as large as a man's head, and larger. The masses are found in a persistent stratum immediately above the Devonian Black shale, sometimes loosely disposed in a greenish or bluish shale, and sometimes tightly packed together in a bed twelve or more inches in thickness. Ordinarily the bed has less thickness, but, thick or thin, it may be said to be universally present, its "kidneys" serving to indicate the place of the Black shale, when the latter is covered or wanting.

3. *The Black Devonian shale*; very generally present, but sometimes wanting and varying in thickness from 0 to 30 feet.

4. *The bed below the Black shale.* The lower phosphate-bearing bed. When freshly broken, a dark bluish gray, or bluish black, more or less granular rock. It shows under the magnifier scattered, white specks and points of pyrites. It has a light bluish streak. This bed, though not so universally present as the bed of concretions above, has a wide range in the region indicated, where it varies in thickness from 0 to 3 and 4 feet. In weathered outcrops it has, as stated, the appearance of a gray or yellowish sandstone; but when freshly broken its dark color appears. Under a magnifier, some specimens show small kidney-shaped grains and now and then minute spiral shells. The presence of fish teeth and fragments of bone in some of it has been referred to.

5. *Limestone.* In some places Hudson River limestone; at other points Niagara limestone.

EDITORIAL COMMENT.

THE COLUMBIAN EXPOSITION.

Notes of Pleistocene Geology.

EXHIBITION OF THE SOILS AND SUBSOILS OF ILLINOIS.

Samples of the diverse soils and subsoils of the great state of Illinois, in which the World's Fair was held, were collected and carefully studied by Mr. Frank Leverett, both in respect to their geological origin and agricultural value, this work being done for the Illinois Board of World's Fair Commissioners, under the direction of Dr. Josua Lindahl, the state geologist. Mr. Leverett's well-known extensive experience in exploration of the glacial drift in this and adjoining states specially qualified him for this investigation, in which also he was aided by Prof. Milton Whitney, of the Maryland Agricultural College, who made mechanical analyses of many of these soils. The collection was on the first floor of the Illinois state building, in cases, a short distance to the left from the main entrance. It comprised about 100 samples of soils and subsoils, ranging in color from black to very light gray or almost white, exhibited in glass trays. So great diversity is due to the chemical and physical characters of the various drift formations which occupy the glaciated area, and to the diverse rock formations whose decay has supplied the soils of the driftless portions of the state. Accompanying this exhibit, a colored map showed the areas of the several varieties of soil and the courses of the marginal moraines, principal eskers, and other drift ridges. A tabular statement of the origin and distribution of these soils, prepared by Mr. Leverett, is as follows:

Soils of Illinois.

VARIETY.	ORIGIN OR MODE OF DEPOSITION.	AREAL DISTRIBUTION.
Residuary.	Decay of the underlying rocks.	Driftless portion of the state, whereever the loess, as well as the glacial drift, is absent.
Stony or boulder-clay, till.	Glacial.	Mainly in the northeastern quarter of the state, where loess and silts are absent. The Shelbyville moraine forms the southern boundary and chiefly the western boundary. In northern Illinois boulder-clays form the soil on the older drift area between the Shelbyville moraine and the loess of the Mississippi valley.
Gravelly.	Glacial overwash, fluvial and lacustrine.	With the boulder-clay, in the northeastern part of the state, and along streams leading away from the Shelbyville and later moraines. This variety of soil includes gravel knolls and ridges, overwash gravel plains, terraces, and raised beaches.
Sandy.	Glacial drainage. Fluvial. Lacustrine. Eolian.	Mainly in basins along the Kankakee, Green and lower Illinois rivers; old lake bottom and raised beaches near Chicago; also on bottomlands and fringing in many places the low bluffs of streams; and locally developed on areas of glacial formations.
Silts pervious to water—(chiefly the typical loess).	Slowly flowing waters, and perhaps wind (in part).	Along the Mississippi, lower Illinois, lower Wabash, and lower Ohio rivers; also between the Illinois and the Mississippi from the Green river basin south to the latitude of Peoria; and in the basin of the Big Bureau creek in Bureau county.
Silts slowly pervious to water.	Slowly flowing waters, and perhaps wind (in part).	Mainly in west central Illinois, west of a line connecting Alton, Litchfield, Pana, Decatur, and Peoria; also on the eastern border of the Mississippi valley loess belt in the northern part of the state.

Silts nearly impervious to water (two kinds, namely, white clays, and gumbo).	Nearly still water; but wind may have had an influence in the deposition of the white clays.	White clays cover much of southern Illinois south of the Shelbyville moraine, as far west as the Mississippi loess, east to the Wabash loess, and south to the Ohio river loess. Gumbo is found along the main rivers, on some bottomlands.
Peaty and marly.	Vegetal accumulations, and shell deposits.	Locally over the greater part of the state, wherever drainage is imperfect. Peat is rare south of the latitude of Springfield, but it abounds in the northeastern quarter of the state, in bogs. Marl deposits are less extensive than peat, but are fully as widespread.

One of the most important results of Prof. Whitney's analyses is the demonstration that the typical loess contains much less fine material (under .005 mm. in diameter of grains) than the impervious silts, or than the boulder-clay or till. The loess has no coarser particles than these silts, and not so coarse as the sandy, gravelly, bouldery till, which was amassed by the ice-sheet. That the loess is assorted in this way, together with the fact that its chief distribution is along the principal waterways, seems conclusive proof that it was deposited by water and not by wind. Professor Whitney has shown that the porosity of soils, dependent chiefly on the fineness or coarseness of their particles, is usually a far more important cause of their fertility or barrenness than the chemical constitution of the materials of which the soils are composed.

Glacial Drift of Chicago and its Vicinity.

A few steps distant from the foregoing, other cases of specimens and small pyramids constructed of glaciated boulders and pebbles displayed the very instructive collection which has been made by Mr. Ossian Guthrie, of Chicago, from the drift in that city and its vicinity, his interest in this subject having been aroused about eight years ago during investigations of the canal routes for the drainage of the city area to the Des Plaines river. Many boulders were here exhibited which had been obtained from the till in excavations for foundations of Chicago buildings, some of these having been derived from rock outcrops hundreds of miles distant in Canada, while others occurring almost in contact with the Canadian erratics were from the Niagara limestone underly ing the city. Mr. Guthrie, in his further search for boulders of Canadian origin, has traversed large portions of Illinois, Indiana and Michigan, and his collection illustrates the dispersal of the drift from the region north of the Laurentian lakes over the country southward.

A peculiar conglomerate enclosing fragments of red jasper, occurring in ledges north of lake Huron, from near Algoma and Thessalon westward to the east end of lake Superior, is found to be distributed by the currents of the ice-sheet upon the region from Cleveland and Cincinnati west to Alton and the Illinois and Kankakee rivers; but none, according to Mr. Guthrie, can be found at Chicago, and it is rare even along the east coast of lake Michigan, although plentiful through the greater part of the lower peninsula of Michigan. Boulders of very coarse agglomerate in this collection, identified by Dr. Robert Bell, of the Canadian Geological survey, as from the district north of lake Huron, were found in the till 700 miles distant, at Alton, Illinois. Pieces of native copper, derived from the lake Superior district, well represented in Mr. Guthrie's collection, occur in the drift in and near Chicago and southwestward to Joliet and La Salle, a mass of 168 pounds having been found a half mile east of the state prison at Joliet. During the maximum stage of the glaciation drift was transported, as these erratics show, from lake Huron far to the south and southeast, and from lake Superior to the south and southwest. Glacial striæ on the bed rocks, admirably exhibited near Chicago and thoughout the greater part of the drift-bearing region wherever the rocks are exposed, partly record these currents; but in many places the striæ, like the moraines, belong to later stages of the glaciation, when the ice currents, during the recession of the continental glacier, were deflected toward the embayments and rē-entrant angles then formed by its irregularly wasting border.

GLACIAL DRIFT AND TRACES OF GLACIAL MAN IN OHIO.

In the Ohio department of the Anthropological building, Prof. G. Frederick Wright, of Oberlin, Ohio, with the assistance of Mr. D. C. Baldwin, of Elyria, and others, exhibited a collection of striated slabs from the bed rocks, and boulders and striated stones from the drift of the state, with samples from the parent ledges of rocks in Canada like the Ohio drift specimens. One boulder of the jasper conglomerate before mentioned, which had been carried by the ice-sheet from north of lake Huron across Ohio to the edge of Kentucky south of Cincinnati, was in this collection, being the same that is shown in the engraving from a photograph on page 63 of Prof. Wright's recent book, "Man and the Glacial Period." This boulder is three feet in diameter and weighs 4,000 pounds. About forty varieties of rocks found in the vicinity of Oberlin were shown as matched with rocks outcropping in Canada, some of these determinations being by Dr. Robert Bell. A duplicate set of these matched boulders and Canadian rocks was also in the Smithsonian collection in the Government building.

The largest mass in this exhibit was a striated slab of the Berea sandstone from Amherst, Ohio, measuring five by nine feet, being the same which is shown in illustrations of page 164 in Prof. Chamberlin's memoir on "The Rock Scorings of the Great Ice Invasions," in the Seventh Annual Report of the U. S. Geological Survey, and on page 52 of Prof. Wright's book previously noted. Another and very unusual phase of glaciation exhibited here was the remarkably fluted surface of the Corniferous limestone from Kelley's island in lake Erie, as illustrated in the same volumes and in Prof. Wright's earlier and larger work on "The Ice Age in North America."

Portions of gravel and sand beds from the glacial plain at Newcomerstown, Ohio, in which Mr. W. C. Mills found a palæolithic implement, were exhibited, having been removed and placed in boxes with glass sides, without destroying the original stratification. On the walls of the space allotted to this collection were photographs of this palæolith and of others from other localities of Ohio, Indiana, New Jersey and the Somme valley in France; and two large maps, drafted by Mr. Warren Upham, presented the leading facts connected with the Glacial period of North America. One of these maps was limited to Ohio and the country immediately adjoining, with the courses of the retreatal moraines of the ice-sheet as mapped by Mr. Leverett, the ancient beaches of the glacial lake Warren south of lake Erie, and altitudes of many towns throughout the state. The other map included all the glaciated portion of eastern North America, the Arctic archipelago, and Greenland, showing the limits of the ice-sheet and glacial drift and the derivation of the Ohio boulders from Canada.

DIVISIONS OF THE PLEISTOCENE PERIOD.

Excellent suites of specimens of the rock formations and fossils of the United States, exhibited in the Government building by the U. S. Geological Survey, comprised samples of glaciated stones, of the boulder-clay or till, of loam from the Columbia formation in Washington, D. C., and of the Mississippi valley loess. On an accompanying placard it was stated that the Pleistocene period included the following divisions: "I. Transition epoch. II. Earlier Glacial epoch. III. Chief interglacial epoch. IV. Later Glacial epoch. V. Champlain epoch. VI. Terrace epoch."

Concerning this subdivision, it may be remarked that the first or Transition epoch was probably characterized by a general epeirogenic uplift of the region which became ice-enveloped. The slow uplifting to such altitude as to give a cold climate and snowfall during nearly all the year, leading to the ice accumulation, may have comprised a longer time than the ensuing epochs of glaciation and departure of the ice, with the deposition of its drift and the stream channelling and terracing of the glacial flood plains. Whether the stages of glacial retreat and readvance during the Ice age should be regarded as marking epochs or subordinate episodes of the Pleistocene period seems at present to be undetermined. Some of the most recent studies of our drift are found to support the view that the glaciation was continuous, moderate fluctuations of the ice-front being thought to be sufficient to account for the forest beds between deposits of till and for eroded drift valleys covered by subsequent advances of the ice-sheet.

MODELS AND RELIEF MAPS ILLUSTRATING PLEISTOCENE HISTORY.

About twenty models of districts and localities in the United States, possessing features of special geological interest, were exhibited by the U. S. Geological Survey. Among these we noted, as illustrative of Pleistocene geology, the series of models of northeastern Iowa prepared under the direction of Mr. W J McGee, with representation of the waning ice-sheet and the lakes and paha-forming streams in ice-enclosed basins and channels; models of the cañons and gorges of the Colorado, Yosemite and Niagara; a relief map of the District of Columbia and contiguous country, with coloring of the Columbia, Lafayette and older formations, by N. H. Darton and G. H. Williams; and a model of Coon butte, Arizona, by Mr. G. K. Gilbert.

The last named locality is so unique, and was the scene of so unusual an event in Pleistocene history, that it deserves special description. Coon butte, as modelled from Mr. Gilbert's surveys, is an annular hill enclosing a crater, situated about twenty-five miles east-southeast of Flagstaff, the railway metropolis of eastern Arizona. The crater is three-fourths of a mile in diameter and 500 to 600 feet below the rim, which is elevated only 150 to 200 feet above the surrounding plain. The surface limestone of the region, elsewhere horizontal, is steeply inclined quaquaversally in the cliffs around the crater; and masses of the limestone and of the underlying sandstone are strown in very irregular profusion outward from the crater to the base of the butte, which has a diameter of about two miles. In less amount the same débris reaches outward on all sides over a nearly circular area to a distance of about four miles. No lava, bombs, lapilli, or other volcanic products, were seen; and the formation of this singular crater, somewhat like the maars of the Eifel district in Germany, is referred by Mr. Gilbert to a steam explosion, probably near the middle of the Glacial period.

The occurrence of hundreds of small fragments of meteoric iron, up to about a pound in weight, and of several larger pieces from 20 to 600 pounds, near the crater and within three miles eastward from Coon butte, one piece also being at a distance of eight miles eastward, led at first to the thought that a meteorite of very large size, surpassing any known example, might have struck this spot, buried itself out of sight, and thrown up a crater rim. This hypothesis, upon being tested, was abandoned because the volume of the raised rim was found by careful measurements to be very closely equal to that of the crater below the level of the plain, and for the second reason that a magnetic survey failed to indicate the existence of any large mass of meteoric iron, competent to make this crater, within at least a depth of many miles. No other American maar is known, and the rareness both of such craters and of meteoric falls strongly suggests some intimate relationship. If a crustal steam explosion made the crater, perhaps the impact of a large meteorite induced the explosion.

Thorough knowledge of the altitude, slopes, and general contour of any region is so indispensable for explorations of the conditions of its Pleistocene erosion by streams, glaciers and ice-sheets, and of the formation of its glacial and modified drift, or of its residuary soils and alluvium if south of the glaciated area, that this contribution can not be concluded better than by noting the several states of which relief maps were exhibited in the state buildings and in the Mines and Mining building. These were New Hampshire, New York, New Jersey, Pennsylvania, Maryland, Illinois, Kentucky, Arkansas, and California. The one on the largest scale was New Hampshire, the most mountainous of the New England states, which was two inches to a mile horizontally, and an inch to 500 feet vertically. This was made by Mr. Cosmos Mindeleff, on the basis of the contoured map published by Prof. C. H. Hitchcock, the state geologist, who has shown that the ice-sheet covered Mt. Washington, 6,293 feet above the sea, there moving southeastward. It was displayed in the state building, and was surrounded by windows which were transparencies of White Mountain scenery. In the exhibit of the U. S. Geological Survey a relief map of the United States, by Mr. Edwin E. Howell, showed the curvature of the earth's surface on a scale of forty miles to an inch, which would make the earth's radius about eight feet, while the vertical scale was exaggerated fivefold, being eight miles to an inch.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Canadian Ice Age: being notes on the Pleistocene geology of Canada, with especial reference to the life of the period and its climatal conditions, and lists of the specimens in the Museum. By Sir J. William Dawson, C. M. G., etc., pp. ix, 301, with numerous illustrations. Montreal, October, 1893.

In this volume of the memoirs of the Peter Redpath Museum of McGill University, Montreal, this distinguished author and veteran geologist has collected and restated his views regarding the Ice age as it occurred in Canada. As is well known to all glacialists, Sir William Dawson has always demurred to accepting the prevalent theory—the Agassizian theory, as it may be termed—of a continental glacier, and has instead thereof steadily insisted upon the doctrine that the glacial phenomena of Canada, at least, may be satisfactorily explained by the action of local glaciers and of heavy floe-ice. Geologists who were present at the Montreal meeting of the American Association for the Advancement of Science will recall the ability and earnestness with which he defended this position against all assaults, and the courtesy and kindliness which marked all the discussions in which he played the double part of host and antagonist.

After a brief review of his earlier published writings on this subject, the author takes up the task which he has assigned to himself and begins with a description of the Pleistocene formations in eastern Canada, which are as follows, in descending order:

Terraces and Inland Cliffs.
The Saxicava sand.
The Leda clay.
The Boulder-clay.

In this series the boulder-clay constitutes the true "till," a hard, gray clay filled with stones and thickly packed with boulders. It rests for the most part on smoothed or striated rock surfaces, and is in some places on the lower St. Lawrence fossiliferous, holding *Leda glacialis* (*Yoldia arctica* Gray), and stones covered with *Balanus hameri* and Polyzoa, indicating marine conditions of deposit. It contains also great quantities of loose boulders, both of local and of distant origin.

The striation of the underlying rock is for the most part in a N. E.-S. W. direction; but in some spots, as in the Mile-end quarries near Montreal, the surface shows four sets of striæ, while very frequently two sets can be found at right angles to one another, of which in eastern Canada the N. E.—S. W. group is, for the most part, on the lower ground, while the N. W.—S. E. group is usually higher. The former the author attributes without hesitation to the Arctic current passing up the valley during a time of submergence, and the latter in general to the local glaciers which more or less filled the lateral valleys, such as those of the Saguenay, Murray bay, and the Ottawa river. At the mouth of the former are grooves on a magnificent scale, some being ten feet wide and four feet deep, being cut into hard gneiss.

To enable ice floes carrying stones to reach the high levels at which striation occurs, a depression of the land is assumed, which converted the St. Lawrence into an arm of the sea and left only the highest points of the Laurentides and Appalachians above the water, thus allowing a vast arctic current to flow over the country of the great Laurentian lakes.

The Leda clay, which constitutes the subsoil over a large portion of the great plain of Lower Canada, varies in thickness from nothing to fifty feet or more, and is in many places abundantly charged with *Leda glacialis* in fine preservation, with the valves united and covered with epidermis. It also contains locally, as near Ottawa, nodules of its own material enclosing numerous fossils, such as leaves and other vegetal relics, and especially skeletons of the capelin (*Mallotus villosus*) and stickleback (*Gasterosteus aculeatus*), fishes still living in the waters of the lower St. Lawrence. Foraminifera and ostracoda also occur in it, and in holding these fossils, as well as in its color and texture, it closely resembles the blue mud now forming in the deeper parts of the gulf of St. Lawrence. Its material has been mainly derived from the wash of the Lower Silurian shales of the Quebec and Utica formations, which occupy a wide space in the basin. The drift has been carried southwestward, and grows thinner and finer in that direction. Its western limit appears to be where the ridge of the Thousand Isles crosses the St. Lawrence river, and where the same ancient rocks cross the Ottawa. Deposits referable to the shores of the Leda clay sea, and to the estuaries opening into it, are not uncommon, and contain such freshwater genera as *Valvata*, *Paludina*. *Planorbis*, *Unio* and *Cyclas*, with occasionally *Tellina*, the last indicating, at least at times, a brackish condition of the water. The beds and fossils of the Leda clay rise to an elevation of 425 feet in places, which would carry a deep sea to the head of lake Ontario, but "no marine fossils appear to have been found on the banks of that lake."

The Saxicava sand frequently rests upon the upper and often much eroded surface of the Leda clay, showing in some places an abrupt and in others a gentle transition, in which latter case its lower layers are richly fossiliferous. It consists of yellow or brownish quartz sand and large travelled boulders, but it rarely contains glaciated stones. It is a shallow water deposit, but "must, when at high levels, have been formed on the margins of deep seas."

Into these three deposits have been cut, during the emergence of the land, a series of terraces, which at Montreal lie 120, 220, 386, 440 and 470 feet above tide. On Mount Royal a distinct beach lies at 615 feet, and travelled Laurentian boulders occur at the very top, at a hight of 700 feet. A conspicuous line on the lower St. Lawrence between 500 and 600 feet seems to mark the margin of the sea in which was deposited most of the Leda clay, and in this deposit marine shells have been observed.

After thus stating the data on which his work rests, the author passes on to discuss the climatic conditions of the time. Assuming, as by common consent, a high late Pliocene position of the land and a deep depression in the Pleistocene, during which the till was deposited, he assigns the Leda clay to a late part of the same depression, a third portion of which is marked by the second boulder-clay, whose boulders were carried by floating ice to the summits of the higher hills and mountains in eastern Canada and New England, or to a hight of 4,200 feet.

From this depression the continent gradually arose, leaving the terraces as evidences of the recession of the waters. Thus came on the second continental period, when the land was more extensive than at present. A southern marine fauna extended far north along our coasts. and great mammals now extinct roamed over the land.

The author's views are illustrated by two maps, showing what, in his opinion, was the geography of North America in the Cretaceous and Pleistocene periods, and leading to a discussion of the effects of the changes of the areas of land and sea upon the climate of the temperate zone. He has no hesitation in ascribing the refrigeration of the Glacial period to this cause, which is, he thinks, amply sufficient to produce all the local glaciers and the floating ice to which he attributes the glacial phenomena.

The venerable Nestor of Canadian geologists may perhaps be pardoned for relieving here the dry details of science by a sally wherein he indulges in a little good-humored banter of his opponents in matters glacial. "Following," he writes, "the example of those geologists of the United States who are in the habit of giving a factitious reality to their palæogeographical views by attaching names to extinct lakes, etc., we may name some of the more prominent features of our map after eminent living advocates of extreme glacial views, whose personal merit and ability, I am prepared to admit, are in the inverse proportion to the probability of their theoretical views. The great southern bay at the bottom of which lies the 'terminal moraine,' may bear the name of Dana. The strait leading to the northeast, where the St. Lawrence now flows, may be Upham strait. The great western opening may well be called Chamberlin sound, and the northern bay, filled with ice, in the region now occupied by Hudson's bay, may be the gulf of Wright."

Then pursuing the line of argument which he has for many years maintained, Sir. J. W. Dawson denies the possibility of a polar ice-cap or a continental glacier. He first asserts that the amount of snow never could be sufficient for the purpose, and secondly, that the evidence is not conclusive and may be read in a different sense. Space will not allow us to follow him into details, but it must be admitted that, so far as Canada is concerned, much that he urges may be allowed, though we can not avoid the conviction that most of the glacial geologists on the south side of the border will object when he attempts to annex the United States to the glacial empire of the Dominion.

In the Pleistocene map three large areas of glaciated land are shown, and from these, in the author's opinion, flowed all the ice that made the glacial era. One of these is Greenland; another is Labrador, with the high land of the Laurentides, to the Arctic Ocean; and the third is the Rocky Mountain region of Canada. The northern Appalachians, New England, and Newfoundland, constitute three other and smaller centers of drift dispersion. The remainder of the northern portion of the continent is occupied by the waters of the glacial seas into which these lands discharged their surplus of ice.

It may thus be seen that Sir William argues for a general lowering of the temperature in the Ice age in Canada, rather than a very severe climate. This was in his estimation the dominant cause of the Glacial period, and in support of his views he brings forward evidence from the flora and fauna of the period, which, he says, bears strongly in that direction. He writes:

"One can to-day dredge in a living state off Metis in the river St. Lawrence all the species found in the upper Leda clay of the neighboring coast. In like manner the vegetable remains of the upper Leda clay and its equivalent in the west are not arctic but boreal plants, and we should have to go near to the arctic circle, then as now, to find the true arctic flora. These facts......show that the climate of the mid-Pleistocene was not an arctic one." (Page 136.)

Passing on next to consider the date of the Glacial period, our author asserts plainly that the results of geological study in North America will by no means allow the distant date assigned by Croll's astronomical theory, but that on the other hand this evidence, though somewhat varying in detail, points with a surprising unanimity to an epoch between eight and fourteen thousand years before our own day as the time of the close of the Ice age. This is of course a very strong confirmation of the view that the dominant cause of glacial conditions was telluric and not cosmical.

To conclude, we will give the author's summary of the conditions of the Pleistocene period in Canada (page 36).

NEWER PLIOCENE.—A continental period of long duration, in which the land was higher than at present, and very extensive erosion of deep river valleys occurred.

PLEISTOCENE.—Covering three subdivisions:—

- (*a*) *Early Pleistocene*, with irregular elevation and depression of the continents, cold climate and great local glaciers.
- (*b*) *Mid-Pleistocene*, with submergence of coasts, re-elevation of interior plateaus, and milder climate.—Interglacial period.
- (*c*) *Later Pleistocene*, with submergence of plains, general ice drift, and local glaciers in the mountains.

EARLY MODERN OR POSTGLACIAL.—Second continental period, in which the land regained almost all the extension of the Pliocene time. Age of the mammoth, mastodon, and of Palæocosmic man.—Postglacial fauna.

MODERN OR RECENT.—Submergence of short duration, terminating the age of Palæocosmic man. Re-elevation of continents to present levels.—Modern fauna.

We cannot follow our author into the local details and the especially useful tables of fossils with which he concludes. However widely we may differ from him on some points, we recognize the timeliness and value of the work. To run to extremes seems inevitable, and the glacial controversy has been no exception to the rule. When the ice-specter reached his full stature, and in the vision of the great master even the valley of the Amazon was ice-enveloped and clogged with morainic matter, when, to the view of some of his followers, the two poles of the earth were alternately so laden and overborne with their ice-caps that the globe was thought to be in danger of losing its balance, the "glacial nightmare" may be considered to have reached its severest incumbency. Since then the pressure has somewhat relaxed. In like manner, our author is, we think, disposed to put upon the theory of floating ice a load greater than it can carry, and to underrate the necessity for more than mere local glaciers to account for the glaciation of the midland states. It is not possible for a geologist residing and working in that region to see in the "terminal moraine" the marginal wash of a glacial lake, when he follows it mile after mile across the country and sees it adapting itself everywhere to all the unevenness of outline and contour, now crossing a high divide, and then plunging down into a river valley, from which anon it rises to continue its former course. To presuppose local elevations and depressions of the surface in order to remove the difficulty, would transcend the scepticism of the most thorough-going unbeliever in the stability of the earth, and would demand more faith than the ordinary geologist possesses.

We cannot resist quoting, in conclusion, with a little condensation, some of Sir William's excellent remarks in his last chapter. He says:—

"With reference to the life of the Pleistocene period, one can scarcely fail to observe that, whatever may have been the lapse of geological time from the period of the oldest boulder-clay to that in which we live, and great though the climatal and geographical changes may have been, we can not affirm that any change, even of varietal value, has taken place in any of the species of the above lists. This appears to me a fact of extreme significance with reference to theories of the modification of species in geological time....... The great elevations and depressions of the land, the extensive erosions, the wide and thick beds of sediment, all testify to the lapse of time. The changes which occurred were fruitful in modifications of depth and temperature. Deep waters were shallowed, and the sea overflowed areas of land. The temperature of the waters changed greatly, so that the geographical distribution of marine animals was materially affected....... Yet all the Pleistocene species survive, and this without change.......

"A second leading thought to which I would direct attention is the relative value of land-ice and water-borne ice as causes of geological change in the Pleistocene. On this subject I have constantly maintained that moderate view which was that of Sir Roderick Murchison and Sir Charles Lyell, that the Pleistocene subsidence and refrigeration produced a state of our continents in which the lower levels, and at certain periods even the tops of the higher hills, were submerged, under water filled every season with heavy field-ice formed on the surface of the sea, as at present in Smith's sound, and also with abundant ice-bergs derived from glaciers descending from unsubmerged mountain districts."

As a parting word we read on the last page: "I shall not attempt to extend these generalizations to the country south of the Canadian border, but must respectfully warn those of my geological friends who insist on portentous accumulations of land-ice in that quarter, that the material can not be supplied to them from Canada. They must establish gathering grounds within their own territory."

Post-Glacial eolian action in southern New England. By J. B. Woodworth. (Amer. Jour. Sci., 3, vol. 47, pp. 63-71, Jan., 1894.)

Pebbles having facettes cut by wind-blown sand are described, and several localities are mentioned where these pebbles occur. From the fact that this carving of pebbles is essentially a subaërial phenomenon, the presence of such pebbles in any formation is proof of an elevation above sea level. The term "glyptolith" (*glyptos*, carved; *lithos*, stone) is suggested for a rock surface carved by wind-blown sand.

The structures, origin and nomenclature of the acid volcanic rocks of South Mountain. By F. Bascom. (Journal of Geology, vol. I, No. 8, pp. 813-832, Nov.-Dec., 1893.)

Three types of rocks are represented in this area: (1) A Lower Cambrian conglomerate and sandstone, and below these (2) brilliantly colored, acid, volcanic rocks, and (3) dark green, basic, volcanic rocks. The author expects soon to present the results of a detailed investigation of these different types, but in this paper only some features of the acid volcanics are discussed. The object is to show that these rocks were originally identical with their recent volcanic analogues, that their present differences are due to changes subsequent to solidification (chief among which is devitrification), and to propose a name which shall express these facts.

A large number of the structures peculiar to modern volcanic rocks are to be found in these ancient lavas, and the presence of these structures is sufficient proof of the igneous origin of the rocks, although until quite recently they have been regarded as sedimentary. An almost universal characteristic of these South Mountain rocks is the micropoikilitic structure of the groundmass. While this structure frequently appears to be an original one, still in most of the rocks under discussion there is excellent proof of its secondary nature. Spherulites and perlitic parting are also present, sometimes in great perfection, and the rock presents in ordinary light the characteristics of a fresh, glassy lava. Under crossed nicols glassy structures disappear and the rock is seen to be composed of finely granular quartz and feldspar, often showing poikilitic patches which run across the lines of perlitic parting. "It is impossible by any description to carry the definiteness of conviction as to the original glassy nature of the groundmass which the character of such rock sections justifies. To one who has studied them in both ordinary and polarized light, there can be no question as to the secondary character of the holocrystalline groundmass." The structures described are: Fluidal, micropoikilitic, spherulitic, axiolitic, rhyolitic, lithophysal, perlitic, amygdaloidal, taxitic and trichitic.

Since devitrified volcanic rocks are quite common and have often been described, the author thinks best that they should be distinguished in some way by name. "If, therefore, we decide to employ this prefix (*apo*) to indicate the specific alteration known as devitrification (*Entglasung*), we may obtain, by compounding it with the name of the corresponding glassy rocks, a set of useful and thoroughly descriptive terms, like *aporhyolite, apoperlite, apobsidian*, etc., as to whose exact meaning there can be no doubt. In accordance with this usage it is proposed to call all the acid volcanic rocks, whose structures prove them once to have been glassy, *aporhyolites*." G.

Ueber ein neues Vorkommnis von Kugelgranit unfern Wirvik bei Borgå in Finland, nebst Bemerkungen über ähnliche Bildungen. By Benj. Frosterus. (Dissertation, Royal Alexandrian University of Finland; 34 pages, 2 plates; Helsingfors, 1893).

About twenty miles west of the well known Rapakivi granite is another granite area, in certain parts of which a beautiful spheroidal granite occurs. This forms a basic facies of the main granite mass, and the spheroids (Kugeln) are more basic still. They are of two kinds, large and small, and do not occur together. The smaller are from two to three centimeters in diameter and are composed of an outer rim of biotite, concentrically arranged, and a core of oligoclase, microcline and biotite with a more or less pronounced radial arrangement. The larger spheroids are twenty to thirty centimeters in diameter and are composed largely of biotite scales concentrically arranged. A discussion of the spheroidal structure is presented and many references are given to places where this peculiar structure has been described. The author concludes that the true spheroidal structure (Kugelstructur) is a primary structure form, that it corresponds to a concretionary development during the crystallization of a rock, and that it has a certain connection with the older, basic secretions.

Geological map and table of economic resources of Illinois. By Daniel W. Mead. This map, which is in black characters, is based on Worthen's map of 1875. The table shows the formations and the localities where the various economic products are found, also short statements of the statistics and value of each. This very unique table contains much useful information, and cost a large amount of study and examination, but is injured seriously by its bad arrangement and very bad printing.

Notes on the hydro-geology of Illinois. By Daniel W. Mead. Read before the Illinois Society of Engineers and Surveyors, Jan., 1893. A very lucid and also comprehensive exhibit of the sources of artesian waters in the state, and a discussion of the chemical impurities of surface waters. Contains many tables of analyses.

La Terre avant l'apparition de l'homme; périodes géologiques, faunes et flores fossiles; géologie régionale de la France, par Fernand Priem. Numerous cuts. Paris. J. B. Baillière et Fils. The object of the author in this work is to pass in review in a pleasing and simple style the changes which the planet has undergone in the different geological periods, particularly the faunas and the floras, pointing out the lines in which they show some connection with existing faunas or floras. He presents a lively view of the general geology of all countries. He dwells more fully on that of France. The treatise evinces a familiarity with the work of recent geologists and paleontologists, and is numerously illustrated with figures of fossils and of geological sections, as well as landscape scenes. The former are very good but the latter are not first-class. The easy, clear style, adapts the work to a wide class of non-scientific readers, and the volume will serve a good purpose successfully of popularizing, without lowering, the science of geology. The publishers send specimens of 32 pages on receipt of 15 cents. We notice the prevalence, throughout, of that peculiarity of French geologists in the use of the term *schistes* alike for shales, slates, and schists. The English geologist fortunately has distinct terms for indicating those three structures.

A contribution to the invertebrate paleontology of the Texas Cretaceous. F. W. CRAGIN. (Geological Survey of Texas. From the fourth annual report.) pp. 141-246; 23 plates of fossils; published June, 1893, Austin.

This important addition to the exact knowledge of the "Texas Cretaceous" corrects some former errors in determinations and carries the identification of species a long march in advance of its former position. Probably since the classic work of Roemer on the paleontology of the state no greater addition has been made to its paleontology. The species described are many of them new, and they have been derived largely from the Comanche series, and from the "Alternating beds." However, a number are also from higher beds. The *Goniolina*, so-called, of the Comanche series was considered by Dr. Roemer, with some doubt, as a species of *Parkeria*, but Prof. Cragin describes it as a bryozoan, *Porocystis pruniformis*. "As ordinarily preserved the fossil resembles a plum or a nutmeg, in form, the surface sculpture not infrequently recalling that of a strawberry."

The species described or identified with other species, are distributed among Cœlenterata, Echinodermata, Bryozoa, Brachiopoda, Lamellibranchiata, Gasteropoda and Cephalopoda.

Republication of Descriptions of Lower Carboniferous Crinoidea from the Hall Collection now in the American Museum of Natural History, with illustrations of the original type specimens not heretofore figured; by R. P. WHITFIELD. (Memoirs Amer. Museum Nat. Hist., Vol. i; pt. 1, pp. 1-37, pls. 1-3, 1893.)

This is the first instalment of a new series of publications by the American Museum and its elegant proportions (large quarto), high grade paper and press work, and lithographic plates by Ast, indicate that typographic and artistic excellence are to be paramount considerations in the make-up of the work. In the preparation of the present paper the author is carrying out a plan already begun in one of the Bulletins of the Museum, to illustrate all type specimens in the collections, not heretofore figured. The Crinoidea discussed were for the most part described by Hall in 1861, in a pamphlet entitled, "Descriptions of New Species of Crinoidea from the Carboniferous Rocks of the Mississippi Valley,"and also published in the Journal of the Boston Soc.

Nat. Hist. for that year; a number were published in the Supplement to the report on the Geological Survey of Iowa (1860). In each case the original description is reproduced with the addition of such information as has since been adduced. This method of treatment makes the work very useful to the student. Forty species and varieties are described, of which but one, *Batocrinus bisbrachiatus* (which, though no doubt a good species, is bad Latin), is new.

Ueber silurische Siphoneen; by E. STOLLEY. (Neues Jahrb. für Mineral. Jahrg. 1893, II Bnd, 3d Heft, pp. 135-146, pls. vii and viii.)

The author describes a number of calc-algæ from Silurian boulders in the vicinity of Kiel, and suggests the probability that many oolites are composed of such organisms.

Recent studies of the Eurypterina, by MALCOLM LAURIE. *On some Eurypterid Remains from the Upper Silurian Rocks of the Pentland Hills.* (Trans. Royal Soc., Edinburgh, vol. XXXVII, pt. 1, No. 10, pp. 151-161, pls. 1-3, 1892.) *The Anatomy and Relations of the Eurypteridæ.* (Idem, pt. 2. No. 24, pp. 509-528, pls. 1, 2, 1893.) *Recent Additions to our Knowledge of the Eurypterida.* (Natural Science, vol. 3, No. 18, pp. 124-127, 1893.)

Mr. Laurie brings to the investigation of some obscure points in the anatomy of these interesting fossils an evident familiarity with recent merostoms and arachnids. The elaboration of the anatomy of *Eurypterus* and *Pterygotus* by Schmidt, from the exquisitely preserved material from Rootziküll, preceded by the work published by Hall, and based upon less favorably preserved specimens from the uppermost Silurian of New York, and the deductions of Salter, Woodward, Hall and Clarke in regard to the composition of *Slimonia* and *Stylonurus*, left some points in doubt, fewer in the former than in the latter genera. As a natural result Mr. Laurie's most important determinations are in regard to the hitherto less known genera, principally *Slimonia*, a genus not known to be represented in American faunas. In this genus the existence of preoral chelate appendages is for the first time established, their presence in *Stylonurus* was shown to be probable by Hall and Clarke; in *Pterygotus*, they have long been known, while in *Eurypterus* Schmidt made out a pair of preoral filamentous appendages lying between the bases of the first pair of walking legs, which have been looked upon as tentacular (*antennæ*; see Zittel's "Handbuch"). Laurie, however, finds indications that this preoral pair was of a more substantial character and probably chelate. The inference is *a priori* a natural one, and if correct establishes a single type of leg structure in all these genera. The author's restoration of the ventral surface of *Slimonia* shows five pairs of abdominal plates or sternites, the members of which rapidly diminish in width backward, each bearing on the inner surface one or more branchial plates. It seems to be satisfactorily demonstrated that sexual differences in this genus are indicated by a variation in the form of the genital plate, though similar differences have not been established in the related genera. A new generic name, *Drepanopterus* (*D. pentlandicus*) is introduced, based upon the proportionally great width of the carapace, but the respects in which this fossil differs from *Eusarcus* and *Eurysoma* are not indicated.

The evidence adduced by the author brings out more forcibly than ever the relations of the Eurypterina to *Limulus*: and if *Limulus* and the merostoms are arachnids, as argued with much force by Lankester, VanBeneden, Peach and others, including the author, then the eurypterids must also be regarded as arachnids. The splendid argument of Thorell against this position has, however, yet to be counterpoised. It is shown that *Limulus* is probably no direct descendant of these ancient merostoms, but has been derived along a lateral stem, differentiated contemporaneously with that of the Eurypterina from the early ancestral stock of both. What this primitive stock may be is not known. The author, whose investigations were made before the recent elucidation of the ventral anatomy of *Triarthrus* by Matthew, Jr., and Beecher, thinks that the trilobites may have been the point of departure, but this view is no longer tenable and it is very doubtful now if the Trilobita and Arachnida (or even the Merostomata) should be regarded as equivalent sub-classes of the *Pœcilopoda.*

CORRESPONDENCE.

Additional Facts about Nicollet. The name *Nicollet* is synonymous in American history with the terms pioneer, explorer, scientist and cartographer. In Canada and the Northwest especially we meet with reminders of early explorations in the frequency with which the name is applied to counties, islands, post offices and city thoroughfares. It is a fact which may not be generally known, however, that there were two French explorers who bore this name, and that they have not always been clearly distinguished. They lived two centuries apart, and yet their given names have been confounded even by historians.

Jean Nicollet, or Nicolet (for his name was spelled in both ways in the Jesuit "Relations"), came to North America at about the age of twenty, in the year 1618. His birth-place is supposed to have been at or near Cherbourg, and the year 1598. "He was a man full of spirit, daring and at the same time deeply religious," and well fitted by these qualities to take a prominent place in the new world.

In a short time he was sent (about 1620) a hundred leagues from Quebec up the Ottawa river, among the Algonquins of Alumette island to learn the language. There he stayed two years without seeing a single European, "always accompanying the barbarians on their expeditions and travels, amid fatigues that can not be imagined except by those who have seen them; several times he passed seven or eight days without eating anything. He was seven whole weeks without other nourishment than a little bark." (Relation of 1643.)

About 1622 at the head of 400 Algonquins he was successful in an attempt to negotiate peace with the Iroquois. Later he went among the Nipissings or Algonquins of lake Nipissing, fifty leagues farther northwest, and remained with them eight or nine years, becoming one of them, adopted by the nation, taking part in their councils, "having his cabin apart, doing his own fishing and trading." He is not thought to have been in Quebec during the time when (1629 to 1632) it was held by the English. But when the French again obtained control he was called to be clerk and interpreter for the Company of the Hundred Associates.

July 1, 1634, he was sent from Quebec by Champlain on an exploring expedition to the west. On this journey it is said that Nicollet "sustained all the hard work of the most robust of savages." With seven Huron Indians for his only companions he coasted along the shore of lake Huron through the strait that leads to lake Superior, to the place since called Sault Sainte Marie, where he remained some time to afford rest for his men. He thence proceeded through the straits of Mackinaw into lake Michigan and landed at the mouth of the Menomonie river on Green bay. From here his course is not definitely known. It is believed that he went up the Fox river as far as the village of the Mascoutins, about where Green Lake county now is, and then turned south to the Illinois country. It is not certain that he ever reached the Mississippi river, although he traveled some distance into the territory west and south of lake Michigan.

He died in November, 1643. "While making a journey to Three Rivers in order to deliver an Indian prisoner, his zeal cost him his life and he was shipwrecked. He embarked at Quebec at seven o'clock in the evening in the launch of M. de Savigny, which was going to Three Rivers. They had not yet arrived at Sillery when a gust of the northeast wind, that had raised a terrible storm on the great river. caused the launch to fill and it sank to the bottom." (Relation of 1643.)

"To-day Jean Nicollet is openly recognized as the one who disclosed the way to the great lakes and the western territory." He has been called the "Jacques Cartier" of Wisconsin, and furnished the earliest accounts of its inhabitants. "In the *Relation de la Nouvelle France*, for 1639-40, is the first list of western tribes, made up from the statement of Nicolet."

These facts are taken from various volumes of the Wisconsin Historical Collections, especially, however, from the French of Henri Jouan, in *Revue Manchoise*, 1886. Translated by Grace Clark. *Wis. Hist. Coll.*, XI, pp. 1-22.

Joseph Nicolas Nicollet* was born July 24, 1786, at Cluses, in Savoy. He showed unusual indications of mental acuteness and energy while still a boy, and was given a first-class education. In order to complete

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**Vid.* Nouvelle Biographie Generale, etc. Dr. Hoefer, *Paris*, 1864; Amer. Almanack, 1844; Am. Biog. Dict., 1857; Querard, France Litteraire; Obituary notice in *Am. Jour. Sci.*, Ser. I, vol. XLV, 1843; J. C. Poggendorff's Biographisch-Literarisches Handworterbuch zur Geschichte der exacten Wissenschaften, *Leipzig*, 1863, vol. II, pp. 286. 1431.

his studies he went to Paris and soon made himself known for his intelligence. He was attached to the Paris Observatory as "secrétaire bibliothécaire" in 1817. He was naturalized in France in 1819 and entered the Bureau of Longitudes in 1823. He received the Cross of the Legion of Honor in 1825. He was at one time both professor of mathematics in the college of Louis le Grand and Examiner for the Naval School. Ruined financially by the depreciation in the value of stocks caused by the Revolution of 1830, he sailed from Brest for the United States in 1831.

In a former number of this journal* is an account of his work in this country. It is not necessary to repeat the facts there given. The following details are in addition.

Among his writings which were not mentioned in the former sketch are: "Sur le mesure d' un arc du parallèle moyen entre le pole et l' équateur," Paris, 1826; "Cours de mathématiques à l' usage de la marine," 2 vols. 8vo, Paris, 1830; "Essay on Meteorological observations, printed by order of the War Department," Washington, 1839.

He presented some remarks on his observations in the west before the Association of Geologists in 1843, the substance of which is given in the American Journal of Science, volume XLV, pp. 153 and 323. The first is on the Cretaceous formation of the upper Missouri river; the second is on the glacial theory of Agassiz. In this latter paper he expressed his astonishment that Agassiz had overlooked the labors of his predecessors in the same field, and particularly of M. de Saussure, who spent forty years in investigating all the glacial phenomena of the Alps and had nearly exhausted the subject. It was, he said, impossible to conceive how the effects ascribed by M. Agassiz to the moving glaciers could with propriety belong to them. The *Mer de glace* was an immense ice-vault, under which, as in a grotto, one could walk even for twenty miles, while on its bottom runs a stream of water. How, then, could the bottom of the *Mer de glace* be supposed to score and furrow the rocks in its path? Moreover, M. Agassiz had overlooked the true effect of the expansion of the ice. He had ascribed to it the downward movement of the glacier, while De Saussure long ago proved that this motion was due to gravity only. Agassiz also overlooked the influence of the direction and shape of the valleys on the direction of the "diluvial furrows."

J. N. Nicollet died in Washington on Monday morning, September 11, 1843, at the age of fifty-seven. He left in manuscript a dictionary of Indian dialects and a collection of Indian songs. In various United States publications his name is given as "I. N. Nicollet," while in the histories of Minnesota it is printed "Jean N. Nicollet," thus confusing it with the earlier explorer. They were both remarkable men and their memory is worthy of being perpetuated. HORACE V. WINCHELL.

Minneapolis, Jan. 9, 1894.

SPIRE-BEARING GENERA OF THE PALÆOZOIC BRACHIOPODA. Palæontology of New York, vol. viii, pt. ii, fascicle i, pp. 1-176, with 155 wood cuts in text, July, 1893. By JAMES HALL, assisted by JOHN M. CLARKE. "An unavoidable delay in the printing of the lithographic plates designed to accompany this volume renders it desirable to issue a part of the edition in the form of fascicles." The first fascicle treats of fifty-nine genera and subgenera, constituting the palæozoic forms of the suborder *Helicopegmata*, or spire bearers. Sixteen of these genera are new, an increase of over thirty-five per cent. The work is illustrated by numerous wood cuts of the calcareous arm supports (here termed *brachidium*), from preparations by Mr. Clarke. Many good and detailed definitions and discussions of the interrelations of species and genera of this suborder are given, but a complete synopsis will require more space than this review admits. Only the more striking conclusions, therefore, will be noticed.

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*Jean N. Nicollet. By N. H. Winchell. American Geologist, vol. VIII, pp. 343-352. Dec., 1891.

In the forty pages here devoted to *Spirifer*, the plan adopted in the previous volume in treating of *Orthis* is abandoned. The latter genus was divided into fourteen groups, each of which received a distinct subgeneric name, thus rendering it very easy to refer to any group. *Spirifer*, however, is divided into six primary sections; *Radiati*, *Lamellosi*, *Aperturati*, *Ostiolati* and *Glabrati*, all of these being again subdivided. Some of the secondary sections have a similar terminology, while other subsections are typified by characteristic species; as *Disjunctus-type*, *Striatus-type*, etc. The number of sections and subsections is thirty. For six of the subsections, the terms *Delthyris*, *Reticularia*, *Choristites*, *Martinia*, *Martiniopsis* and *Mentzelia*, of authors are retained. It is not generally known, however, that the type species of *Delthyris* has a ventral septum, which proves this subgenus to be equal to the section *Lamellosi Septati*, and not to the *Fimbriati Unicispinei*, as given in this fascicle. *Mentzelia* has been regarded as a subgenus of *Spiriferina*, and was so placed by Waagen in 1883 and by Bittner in 1893, but whether this is correct is not now evident.

The above classification of the *Spirifers*, which is based essentially upon surface characters, has been attempted a number of times, but no system has come into general use. It is admitted that *Lingula*, *Orthis*, *Spirifer*, and *Rhynchonella*, with their numerous species, are difficult to classify bi-, or trinomially, yet it would seem as though internal or developmental characters rather than surface ornamentation might aid in the solution of the problem. This suggestion is not intended to convey the impression that the internal organization of *Spirifer* has not been studied, but it is believed that characters do exist in the many species of this genus, which can be used for subgeneric purposes. While knowledge of the interrelations which the species of *Spirifer* bear to one another has been greatly increased by this work, yet the former multinominal method of discussing them is not simplified by it.

Cyrtia, Dalman, is shown to differ from *Spirifer* only in having a high ventral area, with its delthyrium closed by a perforated deltidum. To the list of species should be added *Spirifer metus*, here referred to the "Pauciplicati" of the "Radiati" of *Spirifer*.

Spiriferina is thought to have come through the lamellose-septate spirifers. The same view was also held by the present writer in "A Classification of the Brachiopoda."* If this opinion is true, the progression would not only be through an impunctate to a punctate stock, but would also include a change from an imperfect to a perfect loop, the imperfection of which is thought to have resulted in a partial absorption of a complete ancestral loop. *Cyrtina* agrees with *Spiriferina* in having a perfect loop and a strongly punctate shell, while the other internal characters of *Cyrtina* might easily be modified into those of *Spiriferina*. Which of these views is the correct one can only be proved by an ontogenetic study of some species of *Spiriferina*.

Metaplasia, gen. nov., is typified by *Spirifer pyxidatus*, Hall, to which should be added *S. disparilis* of the Corniferous, although it is referred to the septate-lamellose spirifers in the present work. For another aberrant group of spirifers typified by the European *S. cheiropteryx*, the generic name *Verneuilia* is proposed.

Davidson regarded *Atrypa nitida* Hall, as the type of *Meristina*, proposing *Whitfieldia* for *M. maria*, which is the original type of *Meristina*. *Whitfieldia* is therefore a direct synonym of *Meristina*, and for the latter genus, as understood by Davidson, the term *Whitfieldella* is here substituted. It is a question, however, whether the "unique loop" and "peculiar fulness and close incurvation of the beaks" of *Hindella*, Davidson, render it generically different from *Whitfieldella*, since other characters seem to be essentially alike in both forms.

Hyattella, gen. nov., is based upon *Atrypa congesta* Conrad; while *Dicamara*, gen. nov., is founded upon *Merista scalprum* Roemer, a form occurring in the Eifel and having a "shoelifter" plate for muscular attachment in both valves, while *Merista herculea*, its nearest generic relative, has but one, which is in the ventral valve.

The type of *Meristella* first recognized by Hall is *Atrypa naviformis*, a rare and nearly always imperfect shell. This species was later abandoned by him for *Merista lœvis*, the recognized type species of the genus. Conformity to the rules of nomenclature would not permit this had the genus been defined when the term *Meristella* was first used, but as this was not done, there can be no valid objection to founding the genus upon the second type. *Charionella*, Billings, is revived as a subgenus of *Meristella*.

Camarospira, gen. nov., has for its type *Camarophoria eucharis* Hall. It is supposed to be related to *Meristella* and *Merista*, the loop, however, being unknown.

McCoy's abandoned athyroid genera *Actinoconchus* and *Seminula*, with *Cliothyris*, King, are emended and serve as subgenera of *Athyris*. While surface ornamentation is the most important distinction for their separation, there are internal differences as well. *Athyris* has a lamellose exterior (*A. spiriferoides*); in *Cliothyris*, the "lamellar expansions are divided almost, and sometimes quite, to their bases, into long, flat spinules" (*A. royssii*); *Actinoconchus* has an "extravagant development of the concentric lamellar expansions, which are striated by distant sulci," and "these expansions appear to be fine, tubular spines connected by, or imbedded in a tenuous calcareous plate" (*A. planosulcata*), while *Seminula* has a smooth exterior (*A. subtilita*).

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*AMERICAN GEOLOGIST, vol. xi, 1893. pp. 141-167.

The most primitive athyroid known is *Terebratula læviuscula* Sowerby, of the English Wenlock, the brachial apparatus of which was first demonstrated by Glass to be structurally different from that of *Athyris*, and this species now serves as the type of *Glassina*, gen. nov.

Retzia, King, is shown to possess a very peculiar and unexpected interior structure, which at present is not known to be common to any other species. The many American retzioid forms are here shown to belong to *Rhynchospira*, Hall; *Homœospira*, sub. gen. nov. (type *R. evax* Hall); *Ptychospira*, gen nov. (type *Terebratula ferita* von Buch); *Eumetria*, Hall; *Acambona*, White; *Hustedia*, gen. nov. (type *Terebratula mormoni* Marcou); *Trematospira*, Hall; and *Parazyga*, gen. nov. (type *Trematospira hirsuta* Hall).

Uncites is placed with the retzioid genera, but the nature of the primary lamellæ at their junction with the crura seems to forbid this arrangement, and the family *Spiriferidæ* is suggested by the writer as a more suitable place; *Uncinella*, Waagen, also might remain where its author provisionally placed it, and *Uncites* in the subfamily *Uncitinæ*.

The genus *Anoplotheca*, Sandberger, heretofore little understood, proves, in its known characters, to be congeneric with *Bifida*, Davidson, and *Cœlospira*, Hall. "The structure of the loop is still unknown" in the type species of *Anoplotheca*, and Hall and Clarke state that "with our present knowledge it seems necessary to conclude that the term *Bifida* is altogether synonymous with *Anoplotheca*" (p. 133), in which case it may be assumed that the loop of the latter genus will, when known, prove to be structurally identical with that of *Bifida* as worked out by Clarke. *Leptocœlia*, Hall, which was thought to be a terebratuloid, proves to be a spire-bearer. The structure of its spirals and loop are not yet fully known. From *Cœlospira concava*, *L. flabellites*, the type species "differs, as far as its structure is known, only in its greater size and coarser, simple plication of the surface. In general contour, structure of hinge, cardinal process, muscular scars and internal septa it agrees throughout with *Anoplotheca* and *Cœlospira*." In regard to the latter "it is clearly evident that the structure in the species of *Cœlospira* is essentially the same as in *Anoplotheca venusta*, and *A.* (*Bifida*) *lepida*." For the present, it seems better to merge these unestablished genera into one, *Anoplotheca*, until they can be shown to have a biologic significance.

Vitulina, Hall, also proves to be a spire-bearer and "now takes its place quite naturally in close association with *Cœlospira* and *Leptocœlia*;" *Anabaia*, Clarke, gen. nov., "appears to be the precursor of the Devonian shells referred to *Anoplotheca* and *Leptocœlia*."

Cyclospira, gen. nov., is based upon *Orthis bisculata* Emmons. It is difficult at present to indicate with any degree of exactness the relation which this genus bears to other spire-bearers. However, the nature of the primary lamellæ and of the incomplete loop point to the *Spirifer-*

idæ. The slight introversion of the pauci-spirals in this genus should not be given too great taxonomic value towards the *Atrypidæ.*

In connection with *Cyclospira*, forms are discussed which served Winchell and Schuchert as the types of their genus *Hallina.* These species, *Zygospira nicolleti* and *Z. saffordi*, differ from *Cyclospira* not in the direction of the *Terebratulidæ*, as was at first supposed, but are now known to be clearly related to *Zygospira*, of which they are mature species, neither being an immature stage of *Z. recurvirostra. Z. nicolleti* is regarded as synonymous with *Atrypa exigua*, Hall, upon which is founded *Protozyga*, subgen. nov. It has recently been shown (Proc. Biol. Soc. Washington, vol. VIII, pp. 71-82) that *Z. saffordi* is a more progressive fixed form towards *Z. recurvirostra* than is *Z. nicolleti.* Moreover, since the generic characters of these species are in harmony with *Anazyga*, Davidson, an admitted synonym of *Zygospira*, it is not clear upon what characters *Protozyga* is to stand. Since these stages came into and passed out of existence rapidly and do not have the same value as the fixed stages of development in the *Terebratulidæ*, there can be no great taxonomic value attached to them.

Clintonella, gen. nov. (type *C. vagabunda*, n. sp.), is supposed to be intimately related to *Zygospira*, but the nature of the spirals is undetermined.

Atrypina, gen. nov., is based upon *Leptocœlia imbricata*, Hall, and includes a few forms previously referred to *Cœlospira.* One of these is the well-known European shell, *Atrypa barrandi. Atrypina* is clearly a permanent condition of one of the later ontogenetic stages of *Atrypa.*

The work of Friele, Œhlert and Beecher on the *Terebratellidæ* has shown that it is not safe to propose new genera upon single specimens nor upon a number of specimens apparently, but really not adult. The spire-bearers are no exception to this statement, since we now know that *Zygospira* also passes through a series of metamorphoses. These remarks apply more directly to those genera of the *Helicopegmata* which are based upon the modifications of the loop processes.

For the present work, paleontologists, more particularly those making a special study of the Brachiopoda, owe Hall and Clarke a debt of gratitude. Any one who has tried to develop the brachidium in brachiopods, whether by the aid of acid, sections or pen-knife, will fully understand the difficulties here so successfully overcome. It is evident that the volume when completed, will be a most valuable storehouse of brachiopod knowledge, far outranking all previous works of a similar nature.

Charles Schuchert.

PERSONAL AND SCIENTIFIC NEWS.

J. B. Tyrrell, of the Geological Survey of Canada, and J. W. Tyrrell, Dominion government land surveyor, have recently returned to Ottawa from an expedition to the far north. They went as far as Chesterfield Inlet, on the northwest side of

Hudson bay, traversing 850 miles of hitherto unexplored country. The expedition started from Edmonton May 26th and travelled with canoes by way of the Athabasca river, the north shore of lake Athabasca, Black river and lake, and a river that was followed about 800 miles northward and found to empty into the head of the long and deep fjord called Chesterfield Inlet, which was reached about Sept. 1st. On the Barren Grounds, through which the last mentioned river flows, plentiful herds of reindeer were seen, sometimes many thousands being in sight at once. On the homeward trip along the west coast of Hudson bay to Churchill, a distance of 500 miles, occupying some five weeks up to Oct. 19, the party experienced great hardships from cold and lack of provisions. After remaining nearly three weeks at Churchill for recuperation, the party pushed forward on foot with dog teams to York Factory, Oxford House and Norway House, and finally reached Selkirk, Manitoba, on New Year's day. The total distance traversed with canoes was about 2,200 miles, and on foot and by dog team nearly 1,000 miles.

PROF. I. C. RUSSELL, of Ann Arbor, Mich., gave a lecture on "Mount St. Elias and the Malaspina Glacier," on Friday evening, Dec. 29, 1893, before the Appalachian Mountain Club and invited friends, making an audience of 500 or more, in the Y. M. C. A. hall, Boston. The membership of this Club is about 900.

W. W. CLENDENIN, late assistant to Prof. G. C. Broadhead at the University of Missouri, has accepted the professorship of geology and botany at the University of Louisiana, at Baton Rouge.

TO PALEONTOLOGISTS. J. B. Baillière and Son, of Paris, have just published a paleontological bibliography, which contains the complete titles of more than fifteen hundred works, modern and ancient. It is a pamphlet of 48 pages, octavo, and they offer to send it, gratis, to all geologists who request it.

THE IOWA ACADEMY OF SCIENCE held its regular annual meeting at Des Moines on Tuesday and Wednesday, Dec. 26th and 27th, 1893.

The following papers, on geological subjects, were read:

S. CALVIN—On the geological position of *Benettites dacotensis* Macbride, with observations on the stratigraphy of the region in which the species was discovered.

WM. H. NORTON—Some preliminary notes on the lower Devonian strata of Iowa.

C. R. KEYES—Relations of the Cretaceous formations in northwestern Iowa. Derivation of the unione fauna of the northwest. Process of formation of certain quartzites.

H. FOSTER BAIN—Structure of the Mystic coal basin. The deep well at Sigourney.

E. H. LONSDALE—Southern extension of the Cretaceous in Iowa. Topography of the granite and porphyry areas in Missouri.

A. G. LEONARD—Zinc deposits in northeastern Iowa. Satin spar from Dubuque.

A. C. SPENCER—A Mazon flora in Iowa.

F. M. FULTZ—Interruptions during the depositions of the Burlington limestones.

A. J. JONES—The coal measures of Poweshiek county. On the occurrence of *Cardiocarpus* in Iowa.

T. H. MCBRIDE—Notes on the North American cycads.

Officers elected for the ensuing year are Dr. L. W. Andrews, president; Prof. Herbert Osborn, secretary.

SIXTH ANNUAL MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

This meeting was held Dec. 27-29, 1893, in Boston and Cambridge, Mass. Fifty-one fellows of the Society were in attendance, and fifty-nine papers were presented. The sessions of the opening and closing days were in the hall of the Boston Society of Natural History; and those of Thursday, the 28th, were in the Harvard University museum, Cambridge. The president, Sir J. William Dawson, presided during the greater portion of the meeting, and by his quick wit and genial manners contributed much toward the interest and pleasure of all. Prof. William H. Niles, president of the Boston Society of Natural History, made a cordial address of welcome. He contrasted the time when Sir Charles Lyell visited Boston and the present time. Public feeling then was strongly opposed to the conclusions of geological investigation, but now they are generally acknowledged to be for the best interests of humanity.

The election of officers for 1894 was as follows: president, T. C. Chamberlin, Chicago, Ill.; vice-presidents, N. S. Shaler, Cambridge, Mass., and G. H. Williams, Baltimore, Md.; secretary, H. L. Fairchild, Rochester, N. Y.; treasurer, I. C. White, Morgantown, W. Va.; councillors (term expiring 1896), F. D. Adams, Montreal, Canada, I. C. Russell, Ann Arbor, Mich.; editor, J. Stanley-Brown, Washington, D. C.

Four new fellows were elected at this meeting, namely, Albert P. Brigham, Hamilton, N. Y., William S. Gresley, Erie, Pa., Heinrich Ries, New York city, and James P. Smith, Palo Alto, Cal. The roll of membership now bears the names of 242 living and nine deceased fellows.

The report of the committee on photographs was presented by Mr. J. S. Diller. The especially noteworthy additions to the collection this year are 36 views of American caves, comprising 17 of the Mammoth cave, three of the Wyandotte cave, two of Marengo cave, two of White's cave and 12 of the Luray caverns in Virginia. Fifty other views were obtained, of which Mr. W. H. Hobbs presented 47, illustrating his papers on the geology of the southwestern portion of Massachusetts. The collection of photographs now numbers 802.

Wednesday evening, after the lecture by Mr. Alexander Agassiz, a reception was held in the rooms of the Boston Society of Natural History, at which Mrs. William B. Rogers, Mrs. W. H. Niles, Mrs. Boardman, Miss Bouvé, and others, were present.

Thursday evening the fellows of the Society had their annual dinner at the Thorndike hotel, Boston. Brief remarks were made by the greater number of fellows present, and there was a continual flow of wit and good humor.

The next winter meeting will be held in Baltimore.

On account of the great number of papers to be read, few of them were adequately discussed. In view of this, the general impression seemed to be that the executive committee hereafter should be more rigorous in enforcing time limits, and in sifting out the program; so that more time should be allowed for discussion.

In the following list of the papers read, they are arranged in their order on the program of the meeting. Many of the titles are here accompanied by brief statements of the scope of the papers as in the preliminary announcements of the Society. Of many others abstracts are given as prepared by the authors. Fifteen of the papers were read only by title, these being mostly those of fellows who were absent.

1. *Some recent discussions in geology.* Sir J. WILLIAM DAWSON, Montreal, Canada. This annual address of the retiring president was given in the session of Friday morning. The speaker said that he should restrict himself to matters which had come quite recently before geologists, especially in Great Britain and in this country, and introduced his subject by the statement that since the goal of the science today will be its starting point to-morrow, it is most appropriate at this time to glance at some of the questions now actively discussed among geologists, and to give some suggestions as to their settlement in the future. As these matters are necessarily very various, he would consider them more especially in their relation to the building up and development of the continents on which we live.

Sir William noted first the controversies respecting the age of the older crystalline rocks, the true foundation stones of the continents, instancing those of the highlands of Scotland as described by Geikie and the older rocks of North America as worked out by Logan and his successors. He was inclined to think that the oldest rocks that we shall know are the gneisses of the lower Laurentian, and that these may be regarded as the igneo-aqueous products of the earliest action of the waters on the crust of a cooling globe. He also gave reasons for believing that the whole of the pre-Cambrian rocks may be referred to four great systems,—the Lower Laurentian, the Upper Laurentian, the Huronian and the Keweenian, either in their littoral or their deeper water modifications.

He then referred to the rival theories of mountain-building, and after distinguishing between mountains of eruption (volcanoes), like Vesuvius and Cotopaxi, mountains of slightly inclined strata, like the Lebanon and the Sierra Nevada, and mountains of contorted strata, like the Alps and the Appalachians, noted the diverse views as to the origin of the latter. He favored the time-honored contraction theory as explained recently by LeConte, but saw no objection to connecting with this the deposition theory of Hall and others, the expansion theory of Mellard

Reade, and the isostatic theory of Dutton. When it is necessary to account for the compression of vast masses of rock into a third of their normal dimensions and for their elevation thousands of feet above the level of the sea we may be thankful to invoke all available powers, each in its proper place, and the sculpturing due to atmospheric agencies besides.

This led to a consideration of the uniformitarian and catastrophic theories. While on the one hand geologists are consistent in holding to the constancy of the laws of nature and the uniformity of their action in kind, on the other hand a catastrophe is often merely the culmination of slowly acting causes and is truly a part of the uniformity of nature. The slow crumbling of the face of a cliff is very gradual, but it leads to the sudden fall of vast masses of rock, exposing again new surfaces to infinitesimally slow decay.

He next referred to the slow and gradual accumulations of organic matter as causes and effects of change. He instanced the growth of the coal measures and the relation of this to the gradual subsidence of continental areas, and showed that coal of the ordinary kinds, not including cannel, is a product of subaërial accumulation of vegetable matter, under peculiar conditions, which recurred in various geological periods, but most extensively in the Carboniferous era.

Another subject of much interest in connection with the same general matter is the evidence afforded by fossil plants as to the changes of climate and the geographical causes thereof. He showed by many illustrations how much light fossil plants are capable of throwing on these questions and how strongly they support the idea that the vicissitudes of climate in geological time are mainly due to the different distribution of land and water. In connection with the same subject he showed that the areas of land and water have been sufficiently stationary to support a continuous succession of animal and vegetable life.

Much light is thrown on the vexed question of the refrigeration of the northern hemisphere in the Glacial period when we learn that the ice of this period is local rather than general, and that local glaciers of great magnitude on elevated ground and depressions of lower lands beneath the sea were mainly responsible for this icy episode. Sir William held that no one cause can explain the phenomena of this great refrigeration, but that changes of level and of ocean currents were dominant, that areas of evaporation as well as of condensation were required, and that the succession of deposits can be explained only by a consideration of the changes of physical geography in the successive stages of the period.

He further directed attention to the evidences of an open polar sea throughout the Glacial period, of the great submergence of the land during this time, and of the necessity of abandoning the attempt to account for all of the phenomena by the action of land ice, since we must recognize the effects of sea-borne ice as well as of glaciers. He referred to the evidence now available as to the recency of glacial times and the arguments which suggest vast movements of the earth's crust in periods geologically modern.

The speaker then noticed the opinions lately advanced by a number of leading geologists as to the probability of a great diluvial catastrophe since the advent of man on this globe. He had himself long advocated the necessity for such an occurrence, on the evidence of the extension of the northern continents in the early human period, and the apparently sudden destruction of men and many of the larger animals of the Palanthropic age, producing a vital hiatus between this and the succeeding ages.

This conclusion seems now triumphant and is beginning to bring the geological events of the later Tertiary into harmonious connection with the history of early man as deduced from our traditions and records. He insisted on the importance of distinguishing between glacial and postglacial deposits more carefully than heretofore. Until this is done there will be much confusion, both as to the Glacial period and as to early human remains.

In conclusion, the speaker looked forward to the speedy settlement of these and similar questions in a rational and scientific manner, and in such a way as to establish a stable basis for the work of the future; and he thanked the Society for giving to him this opportunity of pointing out the goals of to-day, which are to be the starting point of the researches of to-morrow. We can estimate the position of the present time, but we cannot easily anticipate that of the future, which with all its wealth of scientific results will belong to the younger geologists, of whom so many are members of the Geological Society of America.

2. *Geological notes on some of the coasts and islands of Bering sea and its vicinity.* GEORGE M. DAWSON, Ottawa, Canada. (Read by Sir J. W. Dawson.) The observations contained in this paper were made during the summer of 1891, while the writer was engaged, as one of the British Commissioners, in the investigation of questions relating to the fur seal. Attention was particularly given to the general physiographical aspects of the lands visited and to the search for possible traces of former glaciation or evidences of recent changes in elevation of the shores. Localities for which the more obvious geological features have already been recorded were not especially referred to, while in other cases more precise details were given. The localities were taken up in the following order: Aleutian islands, Komandorski islands, Kamtschatka, Pribyloff islands, Nunivak island, St. Matthew island, Plover bay. The opinions of Dr. Dall and others as to the absence of any general glaciation in the Bering sea region were confirmed, and remarks were made on the probable date of origin of the Aleutian islands. It was found that a continental plateau probably once connected North America with Asia. The western part of Bering sea has as yet been very imperfectly explored with the deep sea lead. The available evidence goes to show that the submarine plateau and the flat land of western Alaska were covered by a shallow sea during the latter part of the Miocene period, and that afterward the sea bed was probably raised as land, the elevation being sufficient to permit the mammoth to reach the Pribyloff islands. Since the ensuing depression of the region, there has been a recent slight uplift, not exceeding 10 to 30 feet, so far as observed.

3. *The fossil flora of Alaska.* FRANK H. KNOWLTON, Washington, D. C. (Read by Mr. T. W. Stanton.) An historical review of accounts of fossil plants in Alaska, with their systematic enumeration, and a discussion of the geologic age of the beds in which they are found.

4. *New Discoveries of Carboniferous batrachians.* Sir J. W. DAWSON. This paper described recent observations of erect trees whose hollow trunks enclosed fossil remains, in the district of the South Joggins,in Nova Scotia. The first discovery of them was made in 1851 by president Dawson, in company with Sir Charles Lyell. Three beds containing such trees have now been found. The interior portions of the trees rotted away, leaving them as hollow cylinders, into which small land batrachians fell. On their death and decomposition, their bones remained in the trees, intermixed with vegetable débris and soil.

5. *Cenozoic geology along the Appalachicola river.* WILLIAM H DALL and JOSEPH STANLEY-BROWN, both of Washington, D. C. The observations made during a journey from Bainbridge, Ga., down the Flint and Appalachicola rivers to the coastal plain, were summarized. The exploration was undertaken with a view to clearing up some uncertainty in the sections and discrepancies in the stratigraphy, so far as these were previously known. The Appalachicola section, especially the series at Alum Bluff, has become the standard section for correla-

tion of the late Tertiary rocks of the Floridian and Gulf region. In view of its importance, exact measurements were obtained at the best exposures; a triangulation was made for a sketch map, and photographs were taken, at Alum Bluff; and the western extension of the strata on the Chipola river at Bailey's Ferry, Abe's Springs, etc., was carefully studied. The results show that above the Vicksburg limestone the succession of the Miocene rocks is as follows, in ascending order: (1) The Chattahoochee limestone; (2) the Chipola marl; (3) the Alum Bluff beds (subsequently named Aspalaga clays by Johnson),—in all over 80 feet of strata belonging to the older or Chipola (warm water) Miocene; (4) the Chesapeake marl; and (5) the aluminous clay, forming the newer or Chesapeake (cold water) Miocene, with a thickness of about 80 feet more. Above the Miocene strata are about 80 feet of Orange sand, clay, and Pleistocene superficial sands. Correlation with this section renders it probable that the typical Grand Gulf beds (exclusive of the Pascagoula clays, which seem to be newer Chesapeake) are included in a time interval beginning above the lowest Chattahoochee beds and ending with the epoch of the Alum Bluff sands, thus coming entirely within the old Miocene or Chipola epoch. This conclusion agrees in the main with the views of. Prof. E. A. Smith as to the probable age of the Grand Gulf beds, expressed by him in private letters, as early as September, 1892.

6. *Geological activity of the earth's originally absorbed gases.* ALFRED C. LANE, Houghton, Mich. The argument of this paper is as follows:

The earth in its early stages absorbed various gases which it is now giving off in process of cooling. These gases are an original and essential factor in every igneous magma, and their presence is essential and characteristic in the crystalline development of plutonic and dike rocks, their sudden loss in the development of volcanic rocks. Whenever cracks extend far enough down into the earth these gases escape and carry with them the lava, and so become the moving cause of volcanic eruptions. The earth, below the various surface formations, increases in basicity and heat toward a core which probably is largely metallic iron. Lavas furnished from a crack will be at first a mixture of the rock magma at different levels. Their chemical composition will vary according to the depth of the crack and other factors, but will be of medium basicity as regards the material that can be furnished from that crack. Hence any already individualized minerals of pronounced acid or basic character, *e. g.*, quartz or olivine, are liable to corrosion. Acid lavas might be furnished exclusively by shallow cracks. They would have a less high temperature than the basic, and be in a pasty condition. The deeper seated basic lavas would have a higher temperature, hence take a longer time to cool, and so give their vapors more time to escape before consolidation.

The absorbed gases slowly given off from plutonic rocks produce in adjacent rocks the characteristic contact zone. In volcanic rocks the gases escape from the vent, and hence the contact zone is absent or different. These gases are concentrated in the crystallization of plutonic masses into pegmatitic dikes, so that there is a continuous series from pegmatites to segregation veins and true fissure veins filled by ascent, allowing the pegmatites to be classed with either veins or igneous rocks. (The gases are understood, whenever temperature and pressure permit, to pass into the state of hot mineralized water.) If these gases also percolate with extreme slowness outward everywhere, we should expect them to tend to produce a regular graduation in composition from the center out, causing an exchange of material in alternating beds of different composition. The gradual silicification of certain older rocks and metamorphism of crystalline schists may in part be due to this cause, being like a contact zone for the earth's interior. Their action would accentuate the crumpling of the earth's crust by abstracting material below and adding it to the crust. Their escape would also accelerate the cooling of the earth, thus affecting its thermal gradient and the estimates of its age.

7. *Certain climatic features of Maryland.* WILLIAM B. CLARK, Baltimore, Md. A series of large climatic charts, recently prepared for the Maryland State Weather Service, was exhibited, and the effect of the mountainous area in western Maryland and of Chesapeake bay upon the temperature and rainfall were explained.

8. *Dual nomenclature in geologic classification.* H. S. WILLIAMS, New Haven, Conn. Dual designations of geologic formations were recommended, one set of names having reference to the lithological character of the rock-masses and being derived from geographic localities or districts, and the other based on the great and persistent life characters of the fossil faunas and floras of the rocks. The former set of names will be liable to vary as the strata change from place to place, or even a name of lithological significance will have a wide extension when the same conditions of deposition reached far in space or time. The latter names, of biological significance, will be substantially constant over large areas and perhaps over the world. This principle was stated by the author several years ago before the International Congress of Geologists. (Report of the American Committee at the session in London, 1888, p. A91; also AM. GEOLOGIST, vol. ii, pp. 195, 196, Sept., 1888.)

This paper urged the importance of recognizing in nomenclature that duality which is already clearly recognized in the nature of the facts classified. The use of Era, period, epoch, age, as simply chronologic names, and for the correlative structural divisions Group, system, series, stage, is good so far as it goes; it emphasizes the distinction between the geological formations and the divisions of geological time. But it should be carried to its logical conclusion, and different names should be given to things which are different. The author proposes that the present nomenclature, which has been constructed from the outset to designate formations, should be restricted to that use, but should be applied with strict regard to the facts in each case; the same name should be applied only where the same rock formation is actually recognized; and attention should be given to composition, structure and locality, in the definition of the formation. In naming the divisions of the time scale the method and kind of nomenclature already in partial use should be systematized and applied, also with precision, according to knowledge. The longer divisions, Paleozoic, Mesozoic, Cenozoic, are the Times of the geological scale. These are subdivided into arbitrary divisions; the systems, which were originally aggregations of rock formations, and have come to be used as pure time-divisions which are indicated by the fossil contents. If, then, we speak of the Paleozoic time in a tectural sense, it is made up of the five eras named Cambrian, Ordovician, Silurian, Devonian and Carboniferous. Still finer divisions have been determined in each of the eras. In the Cambrian era there are three recognized periods, which may be called Eocambrian, or the early Cambrian; Mesocambrian, or the middle Cambrian; and Neocambrian, or the later Cambrian. The periods are thoroughly understood by geologists throughout the world and are distinguished by their fossils, characteristic genera of trilobites, as defined by Walcott. This system of nomenclature is easily applied to the subdivisions of each of the eras. It is doubtful if the knowledge of paleontology is sufficiently minute to define with precision any universal subdivisions of these periods. Locally epochs and *hemeras* may be recognized in the life-periods of the species and varieties of the fossils. But in most cases the species which are of wide enough distribution to serve as means of definition of the time relations of the fossil faunas have a range geologically through at least one period. Therefore the refinement of the time scale beyond the period awaits the further investigations of paleontologists.

The author used the case of the Catskill sandstone as an illustration. The Catskill "formation," "group," or "period," is a rock formation developed along the northern part of the Appalachian system; but it is not, and it does not represent, any particular geological period of time. In western New York the whole of the Devonian era is represented in stratified deposits without unconformity, and no Catskill formation appears among them. Along the Cayuga lake section the Catskill formation appears at the top of the Devonian system, and is late Neodevonian in age. Along through Otsego and Delaware counties there was a temporary appearance of the Catskill formation in the midst of rocks of early Neodevonian age, called the Oneonta group, but the Catskill proper of that section was formed in the latter half of the Neodevonian. In eastern New York the deposits of the whole Neodevonian are the Catskill formation. In Maine the rocks from the top of the Oriskany sandstone to the Carboniferous all may be defined as the Catskill formation, which is in that region Eodevonian, Mesodevonian and Neodevonian in age. A time definition, therefore, is not appropriate to the Catskill formation, and nothing is to be gained by attempting to use it in that sense.

Prof. ALPHEUS HYATT remarked, in discussion of this paper, that the threefold division of great periods is a matter of much interest. It depends, apparently, on an underlying principle.

Sir WILLIAM DAWSON commented on this, that, if there was anything in a period at all, it must have a beginning, a middle, and an end!

9. Johann David Schoepff, and his contributions to North Amercan geology. GEORGE H. WILLIAMS, Baltimore, Md. This almost forgotten contributor to the geology of our country came to America during the Revolutionary war as a surgeon of the German troops employed by England. His observations upon the geology between the Atlantic coast and the Appalachian mountains from Rhode Island to Florida, and especially in Pennsylvania, Maryland, and Virginia, were published in a book, "Beiträge zur Mineralogischen Kenntniss des östlichen Theils von Nord America," dated 1787, in which he, with remarkable accuracy, foreshadowed most of the recent general conclusions concerning the region. The only copy of the volume heretofore known to be in this country is in the state library at Albany, N. Y., but Prof. Williams found on application that copies of the original edition are still on sale in Germany and can be had at a low price.

10. Relations of synclines of deposition to ancient shore lines BAILEY WILLIS, Washington, D. C. (Read by title.) The data in observations and experiments forming the basis of this paper will be discussed more fully in a memoir, "Mechanics of Appalachian Structure," in the Thirteenth Annual Report of the U. S. Geological Survey.

A syncline of deposition is a trough resulting in strata through subsidence under a locally thick accumulation of later sediments. The definition is independent of the hypothesis that the strata sink because they are loaded, as it is of the alternative theory that the sinking of the strata afforded opportunity for unusually copious deposition. Subsidence has often proceeded as sediments accumulated.

The bulk of sediments is deposited near shore. When erosion is proceeding rapidly in a deep residual mantle, providing great quantities of sediment, the deposit along shore is excessive, and the resulting formation thins gradually seaward. This may be seen in many thick deposits of shale.

Subsiding under such a deposit, older strata will assume a decided dip from the shore to the line of maximum deposition; and they will rise from that line seaward with a gentler inclination.* For instance in Pennsylvania the strata above the great Silurian limestone (III to XII inclusive) measure in the Pottsville basin 23,700 feet, but in Lycoming county they are only 9,700 feet thick. These measures being taken from the once level horizon of overlying coal measures, their base, the limestone, evidently conformed to the curved under surface of the mass of strata in a trough whose form is indicated by the measures of unequal thicknesses. A more detailed statement would show several synclines of deposition indicated by inequalities of thickness in Devonian or Carboniferous strata, which now form the Anthracite basins.

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*Am. Jour. Science, Sept., 1893. "Conditions of Appalachian Faulting," by Bailey Willis and C. Willard Hayes.

Strata have been folded by horizontal compression. They resist compression as struts oppose a thrust. A bent strut yields at the bend; strata forming a syncline of deposition yield in that syncline, which, being folded closer, becomes a syncline of deformation. The decided dip from the shore seaward is in a position to be sharply upturned; it may become vertical or overturned. In this position it may be eroded to great depth without much change in the position of its outcrop, which remains marking approximately the ancient shore line. The application of this method of determining shore lines to the geography of the Appalachian province in Paleozoic time has been found fruitful and it is believed to be reliable. In considering the evidence relating to shore lines, the facts of structure considered in the light of this reasoning appear to be as important as facts of distribution of sediments and of lithologic characters.

11. An account of an expedition to the Bahamas. Alexander Agassiz, Cambridge, Mass. (Introduced by W. M. Davis.) This illustrated lecture by the director of the Museum of Comparative Zoology at Harvard University, was given on Wednesday evening. It summarized the observations taken during cruises of nearly 3,300 miles among the Bahama islands in the early part of last year. A letter describing this exploration was in the American Journal of Science for April, 1893. These islands (as far as to Turk's island) are found to be all of eolian origin. They were formed at a time when the now submarine Bahama banks must have been practically one huge irregularly shaped mass of low land, from the beaches of which successive ranges of low dunes of coral sand, such as still occur in New Providence, must have originated. After the area was thus raised, there was an extensive gradual subsidence which can be estimated at about 300 feet, and during this subsidence the sea has little by little eaten away the eolian lands, leaving only here and there narrow strips in the shape of the present islands.

12. The Later Tertiary lacustrine formations of the West. William B. Scott, Princeton, N. J. The Equus beds are shown by their fauna to be probably Pleistocene, and are separated by a marked unconformity from the Loup Fork. The latter can now be separated into three horizons, characterized by decided differences in their faunas. Of these the oldest is the Deep River formation of Montana, which is known only in the valley of that river. The second, which may be called the Nebraska, is developed on a vast scale from South Dakota to Mexico; while the third, named the Palo Duro formation, has been found overlying the Nebraska in Texas and northern Kansas. The last appears to be the equivalent of the Archer fauna of Florida, which on stratigraphical grounds Dall regards as Pliocene. In tabular form these horizons may be arranged as follows:

Pleistocene.	Equus beds.	
Pliocene.	Peace Creek. Blanco.	
Upper Miocene.	Loup Fork.	Palo Duro and Archer = Hippidium beds. Nebraska = Cosoryx beds. Deep River = Cyclopidius beds.

Morphological palæontology requires that correlation of these horizons with those of the old world be attempted. For this purpose the mammalian fauna is well adapted, because of the repeated land connections between the continents. The isolation of South America produced an altogether peculiar fauna and it is well-nigh impossible to determine the exact equivalents of its various fresh water Tertiaries. Between Europe and North America three points appear to be well established: (1) The Wasatch Eocene = the Suessonian; (2) the White River = the Oligocene of Rouzon; (3) the Deep River = the upper Miocene of Sansan.

13. Geology of the Coosa valley in Georgia and Alabama. C. WILLARD HAYES, Washington, D. C. The region described lies between the Rome and Cartersville thrust faults. The rocks are from Cambrian to Carboniferous, inclusive, and present interesting stratigraphic problems in unconformities and wide lithologic variations in contemporaneous deposits. The structure has resulted from two or more periods of epeirogenic activity, in which the forces acted in different directions, probably separated by long periods of denudation.

14. Geological structure of the Housatonic valley lying east of Mount Washington, Massachusetts. WILLIAM H. HOBBS, Madison, Wis. (Read by title.) The rocks outcropping within the area are schists and limestones of Cambro-Silurian age. Prof. J. D. Dana's papers on the area have expressed his belief that there is a single limestone horizon and a single schist horizon above it. The author shows that here, as in Mount Washington, the series is divisible into four members, viz: (a) Canaan dolomite, which contains colorless pyroxene and rests conformably on Cambrian quartzite; (b) Riga schist, which contains macroscopic garnets and staurolites; (c) Egremont limestone, without pyroxene; and (d) Everett schist, free from garnet and staurolite. The areal geology is unusually complicated, due to the pronounced corrugation of the beds along their strike as well as in a direction across it. The effect of this has been to produce numerous large and small lenticular schist islands within the limestone. Notwithstanding the frequent alternations of pitch, the general pitch is north, occasioned by the rise of a core of more ancient rocks just south of the area studied. An important strike fault with easterly hade has its course along the Housatonic river on the east of the area and has been traced about ten miles. This fault partakes of the characters of both the normal and reversed types, due to the fact that the rocks to the east have no pitch while those of the western limb have a northerly one. As a consequence, the eastern limb has been upthrown uniformly, while there has been a differential movement of the western limb, that to the north of a nodal point having been downthrown, while the portion to the south of the same point has been upthrown. At a small distance from the nodal point the upthrow of the western limb has been greater than that of the eastern limb, thus producing the characters of a normal fault. The dislocation has produced metamorphism in the beds adjacent to the fault plane.

15. The Hibernia fold, New Jersey. J. E. WOLFF, Cambridge, Mass. A brief description was first given of the general characters of the Archean rocks of the New Jersey highlands, and the few distinct varieties of rock were enumerated. These include gneiss, generally white, gray or greenish in color, pegmatite, dark colored basic bands, crystalline limestone and the magnetic ore deposits. The pegmatites and part of the dark dioritic bands cut across the gneisses and are probably intrusive. The great uniformity in strike and dip of the foliation of the gneisses was mentioned, and the frequent pod-shaped form of the ore deposits, the longer axes of which lie in the strike, but incline or "pitch" northeast. The fact was emphasized that this "pitch" of the ore bodies is widespread in the gneisses, either combined with plane-parallel foliation or existing as the only structure in otherwise massive gneisses, so that a surface across this structure may appear massive, while on a side parallel to it this linear-parallel structure is very distinct. It is sometimes plainly connected with the crumpling of the gneisses, but in the massive varieties this is not evident; in all cases it is inherent in the form of the minerals themselves, which have a more or less marked longer axis in the direction of the "pitch" and show no sign of mechanical strain, so that they must have crystallized under conditions compelling them to take this form. The problems connected with the areal geology of the region are as to the origin of the rocks.

The Hibernia region specially described contains one of the largest ore deposits of the State, which is in bed form, having a mile of outcrop and having been worked in the dip 600–700 feet down. This strikes N. E., with a moderately steep dip S. E. The gneisses on the foot-wall side of the ore bed show generally imperfect foliation, but very distinct pitch, which can be followed several miles S. W. from the ore-bed; just opposite the north end of the ore outcrop the pitch is replaced by a N. W. strike of the gneisses and a N. E. dip in the direction and with about the angle of the former pitch. In this way individual beds of gneiss can be traced from both the foot and hanging wall sides of the ore into this northeastwardly dipping series, which gives us a true stratigraphic section of several thousand feet in thickness measured on the axis of the dome. This series to the west loses its banded character and turns into northeastwardly striking and pitching gneisses. As further proof of the stratigraphic order of this series, a band of distinctive rock containing garnets, biotite, and graphite, lying many hundred feet above the ore, was traced completely around two-thirds of the dome and along the east side, and was found in place on the west side. It was therefore claimed as proven, that, whatever may have been the origin of this series of rocks, they are arranged in stratigraphic succession, with a top and bottom and at least one distinct and traceable horizon, and that the structure called "pitch" was closely connected with the folding of the rocks. This is believed to be the first or almost the first succession definitely established by areal geology in the gneissic or Laurentian complex.

16. *Tertiary dislocations of the Atlantic coast of the United States.* N. S. Shaler, Cambridge, Mass. The author has, in several papers, called attention to the evidence of mountain-building stresses in Tertiary and Cretaceous beds on the island of Martha's Vineyard. That these distortions were not produced by the shoving action of the last ice advance is shown by the fact that the folded strata were denuded into hills and valleys before the last glacial drift was deposited upon the island. Recently Mr. J. B. Woodworth, of the U. S. Geological Survey, examined the similar distortions of Block Island and found them closely to resemble those of Martha's Vineyard. While the age of the Block island beds is not yet clearly determined, they are in part, at least, Pleistocene, and have a topography newer than the distortions and older than the last glacial epoch. It is evident that the Atlantic coast has been the seat of considerable mountain-building since the Triassic period; the disturbances of the Triassic or Rhætic beds having taken place in the Jurassic period, or at least before the deposition of the Cretaceous beds. The disturbances described on Martha's Vineyard and Block island, it seems clear, were not local. The action of similar forces has been traced southward by McGee and others along the coast. The occurrence of faults in the south and folds in the north finds its parallel in what we observe in the movements at the close of the Carboniferous period. In eastern Tennessee are mainly faults; in southwestern Virginia folds become more common, and thence northwardly they increase in relative importance. These dislocations are thought by the author to indicate that the immediate coast region is the seat of mountain-making forces which have ceased to act in the Appalachian system. They afford additional evidence that a coast line is the seat of orogenic action.

The Martha's Vineyard folds appear to be the most recent in the eastern portion of the United States. Their extreme compression indicates a renewal of mountain-building forces in a district which has long been denuded and exempt from such accidents. As to whether the action is still going on, the author states that no movement has taken place since the cycle of erosion in which the topography older than the last ice advance was developed. There is no evidence to show that the folds in the Cretaceous and newer strata correspond to a series of anticlines and synclines of the underlying crystallines. Professor Shaler thinks the conditions of folding were analogous to those in the Richmond coal basin, where the Mesozoic rocks have been thrown into sharply dislocated attitudes by the formation of a synclinal trough in the underlying crystallines. A trough of this kind may be produced by faulting. In the case of Martha's Vineyard there is no trace of a seaward side of such a trough, but it should be said that the crystallines of this shore decline rapidly seaward. The organic movements of southeastern Massachusetts occurred shortly after an extensive importation of detritus rapidly accumulated, a fact which tends to confirm the hypothesis that transfers of sediments in some way excite mountain-building action.

Notwithstanding the crumpling of the strata on Martha's Vineyard, there was not much massive elevation. The present shore line is near the old one. Numerous deposits of Cambrian and Carboniferous age in southeastern Massachusetts contain shallow water sediments, and indicate, in the author's opinion, a tendency of the land in this district to return to the level which it has at present.

17. *Relations of mountains to continents.* N. S. SHALER. The author notes that mountains appear to be limited to continents or to large islands continental in their relations. The islands of the oceans are volcanic peaks or peaks brought to the surface by coral-buiding animals. The absence of mountains rising from the sea-floor and their presence in continental areas leads to the assumption that there is some causal relation between the growth of continents and the dislocations of strata which occur on them. Some years ago the author examined the Italian peninsula and was convinced that, with the folding and other compressive phenomena of the mountain axes, there has been a progressive uplift on each side of the disturbed area. This movement appears to indicate that the folding and faulting have been accompanied by a wide-spread movement of the underlying rocks towards the seat of disruption, in a way to support the uplift and to elevate a broad belt. In many cases the highlands adjacent to mountains are due to sedimentation from the mountains; but, making allowance even for this, it is still evident, the author thinks, that the pedestal feature is a normal element in mountain growth. This is shown in North America by the Cordilleras and the Appalachians. The Mississippi valley is a trough formed by the opposed slopes of these pedestals. The amount of the material which has moved in toward mountain tracts appears to be sufficient to account for much of the hight of the continents above the oceans. According to this view, the continents are to be regarded, so far as they have been dry lands, as the product of mountain-building forces. The primal action is the deep-seated migration of matter toward the axes of disturbance, and a consequent elevation of the region where the movements occur; a secondary action arises in the erosion and removal of a portion of the highlands. This last is strongly contrasted with the first.

For the original elevation of the continental arches, Prof. Shaler appeals to the rise of submarine folds to the surface of the sea. Those which fail to reach the sea-level constitute one class, and those that attain the condition of land are by the process of erosion led to a rapid upper development.

18. *Phenomena of beach and dune sands.* N. S. SHALER. This paper

sets forth some observations of the author made in connection with his work as geologist of the U. S. Geol. Survey. One of the noticeable features of beach sands is their endurance to the beating of the waves. Pebbles wear at a very rapid rate. The sands of a beach are held apart by a film of water, which protects the sands from mutual abrasion. Professor Shaler concludes that from this circumstance arises the protection which sand beaches afford the land areas against the assaults of the waves. The absence of sand beaches on small islands is attributed to the lack of sufficient material eroded from cliffs to make considerable accumulations of that nature. The sands of beaches are augmented by the action of large sea-weeds, which transport pebbles and strand them on the beach. Shells are also borne in from the bottom in the same way. Floating pumice is also contributed to the sea-beaches, particularly on the Florida coast, the amount diminishing toward New England.

Dune sands are often found with a dry surface in a few hours after a heavy rain. Professor Shaler has observed that after a summer rainfall of an inch the dune sand would often not be wet for more than three-forths of an inch from the surface, below which layer the sand was quite dry, water not being met with until some feet down in the mass. This phenomenon is explained as due to the repulsion of the water by the dry sands and to the greater ease with which the water flows down the slope through the wet crust until it reaches the bottom of some depression in the dunes, where it percolates downward through the mass. Owing to this shedding of rain, dunes may become dry in a few hours after a rain and be excavated by a strong wind.

The material of dunes where it has remained in repose for years is subject to solution and decay, as is shown by much fine dust, which is absent in recent dunes and beach sands. The fine dust is blown away in the march, and thus hinders the advance of the dunes by diminishing the amount of the material left in the hills. The decomposition indicated by the dust serves in another way to check the advance of the dunes by fitting the surface to sustain plant life, particularly the grasses. Organic matter derived from the beaches acts as a decomposing agent, and this decay is rapidly promoted by the vegetation growing on the dunes, so that the distance to which a dune can travel in ordinary climatal conditions is never very great.

19. The eastern boundary of the Connecticut Triassic. W. M. DAVIS, Cambridge, Mass., and L. S. GRISWOLD, Dorchester, Mass. After illustrating the general structural features of the Triassic belt by a series of lantern slides, the authors maintained that the eastern boundary of the formation, where it adjoins the crystalline plateau, is defined by a series of faults, whose existence is proved as follows: Different members of the formation successively terminate along the eastern border; in passing northward from the sound near East Haven, to the Connecticut river near Middletown, the lower sandstones, the anterior trap sheet, the anterior shales, the main trap sheet, the posterior shales and sandstones, the posterior trap sheet and the upper sandstones and conglomerates, all gently undulating in northeast and southwest dips, are terminated in alternating succession, without regard to their undulations, but with remarkably consistent regard for the presumable course of the hidden fault lines. This cannot be explained as a result of a variable overlap of the several members of the Trias on the crystallines, for the former dip towards the latter. The stratified beds, with the conformable lava sheets, must be abruptly cut off along their eastern margin. The margin is marked by a depression, wider open when the adjacent rocks are weak, narrow when they are hard; but continuous all along the boundary. Close to this depression, departures from the prevailing dip of the formation are frequent; in one place the departures amount to an overturn; brecciated masses of sandstone and trap are also found along the margin. The crystalline rocks near the border manifest the effects of shearing, although now reconsolidated. The shearing is believed to be a result of the marginal faulting, after the deposition of the Triassic beds, because fragments of the reconsolidated sheared rocks are not found among the pebbles of the marginal Triassic conglomerates.

The eastern boundary of the Trias follows an alternating north and northeast course. This is particularly apparent north of Middletown. Hence two systems of faults are inferred; one having a northerly course, the other trending northeast. Two members of the latter system have been traced for many miles obliquely across the Triassic belt, as well as along the oblique portions of the border. In consequence of the combined movements of the two systems of faults, the formation as now exposed broadens northward; and in the Manchester district it is believed that the under sandstones, ordinarily seen along the western side of the monoclinal belt, are brought up and repeated along the eastern border.

20. *Geographical work for state geological surveys.* W. M. Davis, Cambridge, Mass. (Read by title.) The work of our state geologial surveys does not at present come into close touch with a large number of our people. On the other hand, the teaching of geography in our schools is in a lamentably impoverished condition, chiefly because the teachers have no accessible source of fresh information concerning the physical features of their home states. It is the object of this paper to suggest a remedy for both of these difficulties.

It is believed that if every annual report of a state survey contained a chapter on some group of local physical features, prepared with especial regard to consultation and quotation by teachers of the state, a new interest in the work of the surveys would be aroused and a new vigor would be infused into the teaching of geography. In order to carry out this proposition successfully the work should be in the hands of trained geographers, just as studies in paleontology and petrography are in the hands of trained paleontologists and petrographers, properly educated in these branches of the general science. Relatively simple features should be treated first; their systematic relations to features of the same kind in other parts of the world should be clearly brought out by descriptions, illustrations and maps; the dependence of population and occupation upon the natural features should be emphasized. The chapters should be brief enough to attract readers who are not accustomed to research in libraries; hence the advisibility of attempting the account of only a small part of a state in one report. In this way, an appetite for more material of the same kind would be created, while the expense that would be required for this division of the survey work would be a small part of the annual appropriation. In order to gain a wide circulation for the geographical chapter of the survey report it might be reprinted in the report of the state superintendent of public instruction and this issued as a pamphlet for distribution to the public schools. It can hardly be doubted that if this plan were successfully carried out an effective co-operation between the surveys and the schools would result, and both would be benefitted and strengthened by it.

21. *Facetted pebbles on Cape Cod.* W. M. Davis. Referring to suggestions received from his colleague, Mr. J. B. Woodworth, by whom an account of wind-blast carving has been prepared for the American Journal of Science (January, 1894), Prof. Davis briefly described the occurrence of facetted pebbles in the gravels of Cape Cod. At Highland Light the pebbles now exposed in a gravel bed at the top of the bluff are in process of carving; specimens can be had in plenty. Along the southern side of the Cape, where the sea has cut a low cliff in the gravel

plain, facetted pebbles may be frequently found at depths of several feet below the surface, and in practically all cases the facetted side of the pebble lies upward. From this it is argued that the shaping of the pebbles was effected after they were brought to their present positions; and hence it is further argued that during the growth of the gravel plain it must have been a subaërial delta, built by streams heading in the ice sheet among the hills of the terminal moraine, the "backbone" of the Cape. As in ordinary deltas, a portion of the deposit must have been laid down beneath the water-level; but another portion must have been built above water-level; and the facetted pebble beds of the Cape seem to belong to the latter. Until the division between these two portions of the stratified sands and gravels is identified, the postglacial changes of level in Cape Cod cannot be determined.

In the discussion following this paper, Mr. G. K. GILBERT referred to a locality about fifteen miles east of Watertown, in northern New York, where the carving of pebbles by the natural sandblast has apparently been accomplished since a recent clearing of the surface. Prof. SHALER objected to the assumption that the facetted pebbles were carved by wind-blown sand; he thought it more likely that they were shaped by splitting on joints that had been opened during some retreat of the ice; after which a new advance carried the pebbles forward again. Prof. DAVIS replied that, while such weathering might naturally happen, he could not appeal to it to explain the forms of firm-textured pebbles, waterworn on one side, sharply facetted on the other, lying with facets uppermost in undisturbed stratified deposits, several miles from the moraine in which the sands and gravels were derived.

22. *Paleozoic intra-formational conglomerates.* CHARLES D. WALCOTT, Washington, D. C. (Read by title.) An intra-formational conglomerate is one formed of material derived from and deposited within a formation. The paper described conglomerates of this type occurring at various Paleozoic horizons in the St. Lawrence valley and along the Appalachians from Canada to Alabama.

23. *Paleozoic overlaps in Montgomery and Pulaski counties, Virginia.* M. R. CAMPBELL, Washington, D. C. (Published by permission of the Director of the U. S. Geol. Survey.) The region along the Norfolk & Western railroad, between Christiansburg and Max Meadows, Virginia, is an area of very complicated geology. The prevailing ideas are that it is traversed by numerous faults, many of which are transverse to the general lines of structure; and they have been so described by Rogers, Lesley, Fontaine, Stevenson, and McCreath and d'Invilliers.

During the present season the writer worked this region quite carefully, and came to the conclusion that all of these supposed cross faults are in reality lines of unconformable deposition between Devonian and Carboniferous sediments and the Cambro-Silurian or Shenandoah limestone. Price mountain is the best known of these areas and consists of an isolated anticline of Lower Carboniferous coal-bearing rocks, entirely surrounded by the Shenadoah limestone. Everywhere around the mountain the red shale at the top of the Carboniferous rocks is in contact with the limestone and appears to be but slightly disturbed; dips vary from 15° to 30° away from the axis in all directions, while the structure of the limestones, so far as could be seen, is extremely complicated and shows no agreement with the upper beds.

No theory of faulting could place the mass in its present attitude and relation to the limestone, and the writer was forced to the conclusion that it was unconformably deposited in a basin produced by folding of the limestone and was later upraised and folded into an anticline. The same evidence was found in Ingles mountain, where the Devonian black shales rest on the limestone; and in the region north of Pulaski the same phenomenon is seen, and again from Max Meadows to Clark's Summit.

The most important evidence was the observation, on the north slopes of Draper mountain, of three small bosses of the Shenandoah limestone projecting up through an extensive area of only slightly disturbed Devonian shales; these seem to furnish incontestible proof that the shales were laid down on a folded and eroded surface of Shenandoah limestone.

This has a wide bearing on the structure of the entire province, for it marks a period of folding that occurred about the beginning of Devonian time and one in the Lower Carboniferous, and shows that a portion of the valley was dry land during Devonian times.

24. The Trias and Jura of the Western States. ALPHEUS HYATT, Boston, Mass. The author announced the following results of his studies upon the fossils of these two systems: The Trias, or at least a *Monotis* fauna having the aspect of a member of the Trias, has been found by Dr. Curtice while collecting for the U. S. Geological Survey in American cañon, south of Cisco, California. Just above this horizon there occurred a *Daonella* bed, and next above this a bed containing numerous *Ammonitinæ*. The *Daonellæ* were supposed to be Triassic until it was found that they passed sporadically into the *Ammonites* bed. The *Ammonitinæ* are of doubtful affinity, and it was found impracticable to decide whether they are Liassic or Triassic, because no sutures are preserved in any of the numerous examples. With these were also two species of rugose *Aptychi* not hitherto found below the upper Lias in Europe.

The Mesozoic rocks of Sailor's cañon and American cañon to the lower limits of the Snow Mountain tuffs contain a similar fauna, and none of them are younger than the Lias nor older than the Trias.

The announcement was made of the rediscovery of a number of Gabb's Triassic and Jurassic types, and among these were fossils from New Pass, Desatoya Mts., Nevada, which showed the occurrence of a fauna like that of Humboldt county to the west in Nevada, and that both are Muschelkalk. Gabb's types of *Ammonites nevadanus* and an associated species of *Coroniceras*, described as new, show the existence of the lower Lias in Esmeralda county, Nevada, thirty miles from Walker's lake. A collection of fossils loaned by Prof. Thomas Condon of Eugene City, Oregon, contains species identical with some of those found at Taylorville, Cal., in the Hardgram sandstone of the Upper Lias. Gabb's types also demonstrate the existence of the same sandstone at the Walker's lake locality, or Volcano, as Gabb named that region; and the fauna of this horizon in the Upper Lias is found at all three of these widely separated localities.

The fossils collected by the officers of the U. S. Geological Survey during the last four or five years represent the rocks of the western slope of the Sierra Nevada fairly well. These consist of *Aucellæ* and *Ammonitinæ* and some other less important and less characteristic fossils. The *Ammonitinæ* mainly belong to the genera *Perisphinctes* and *Cardioceras*, and these may be closely affiliated with species of the Russian faunas of the Upper Jura. The *Aucellæ* associated more or less with the *Ammonitinæ* tell the same story. They are all striated species and quite distinct from the smooth forms of the Knoxville slates. The *Aucellæ* occur in similar association with *Cardioceras* and *Perisphinctes* in the faunas of the Upper Jura in Russia; and their relations to the species of the same genus in the lower part of the Knoxville slates show that the Gold Belt series contains older faunas. These fossils were mainly from Mariposa, Calaveras and Tuolumne counties in California.

Gabb's type of *Perisphinctes* (*Amm.*) *nevadanus* was among those lately found, and it demonstrates, together with some other similar species collected by the U. S. Geological Survey near Colfax, that the dark slates of that region are also Upper Jurassic.

[TO BE CONTINUED.]

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A MEDIAN HORNED RHINOCEROS FROM THE LOUP FORK BEDS OF NEBRASKA.*

By J. B. Hatcher, Princeton, N. J.

Hitherto no median horned rhinoceroses have been reported from the western continent. During last April and May, while engaged in explorations for the Princeton Scientific Expedition of 1893, in the Loup Fork beds of Sheridan Co., Nebraska, the writer had the good fortune to secure, among other interesting vertebrate fossils from these beds, the remains of a rhinoceros with a well-marked, median, nasal horn.

The material secured, while clearly belonging to the Rhinoceridæ, represents, nevertheless, a new genus of that family, which may be called *Teleoceras* in reference to the position of the horn on the end of the nasals. The species may be called *major*, in reference to its size, which is decidedly greater than that of any other known *American* member of the Rhinoceridæ.

The type specimen of *Teleoceras major* consists of the greater portion of the skull and lower jaw. These represent an animal about one-third larger than *Aphelops fossinger* (Cope). The teeth are very much worn, showing the individual to have been fully adult. It is readily distinguished from all known genera of the *Rhinocerida* by the following combination of characters: Absence of a *crochet* and presence of an *anticrochet* on the superior molars and premolars; with the presence of a sagittal crest (?) and of a median horn situated on the extreme point of the nasals. This horn is directed forward and upward, and extends considerably beyond the extremities of the nasals proper.

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*Separate copies of this paper were published Feb. 1, 1894.

The principal specific characters are: *Post-tympanic* and *post-glenoid* processes confluent throughout two-thirds their length, entirely enclosing the *external auditory meatus.* Pterygoids slightly bifid. Anterior border of posterior nares on a line with posterior border of median sinus of second molar. Nasals not co-ossified. The structure of the teeth is very much obliterated by the wear to which they were subjected before the animal died. The inferior and superior molars are all represented in the type specimen, as well as the fourth upper and lower premolars. Of the superior dentition the second and third molars are the least worn, and, therefore, present the most trustworthy characters. The *dorsum* is very flat. The *median costa* is entirely wanting, and the *anterior* and *posterior costæ* are but weakly developed. The *anterior sinus* is quite small and the *anterior vallum* is not strong. The *median sinus* is well developed and obstructed by a very large *anticrochet* and a small *crista*, but there is no *crochet*, as before stated. The *posterior sinus* is of ordinary size with a strong *posterior vallum.* In the last upper molar *only* there is a distinct *median tubercle.* In the type specimen the first upper molar and fourth premolar are so much worn that the enamel at the bottom of the median sinus, between the base of the anticrochet and the opposite side, has been removed, thus cutting off the inner portion of the median sinus, which now appears as an anterior fossette. By the same wear the enamel once covering the posterior vallum has been entirely removed in these teeth, and as a result the posterior sinus now appears as a posterior fossette. The *anterior borders* of the upper molars and premolars are convex, the *posterior* borders concave, excepting that of the last molar, which is convex. The molar and premolar teeth are very large in comparison with the skull, and the maxillaries are proportionately strengthened in order to receive them. The inferior molars and premolars seem to present no distinctive characters.

To the kindness of Prof. W. B. Scott, who had charge of the expedition, I am indebted for the privilege of publishing this preliminary notice, which will be followed later by a full description, with figures, of this and other material from the same beds.

NEW SPECIES OF CRINOIDS AND BRACHIOPODS FROM THE MISSOURI HAMILTON.

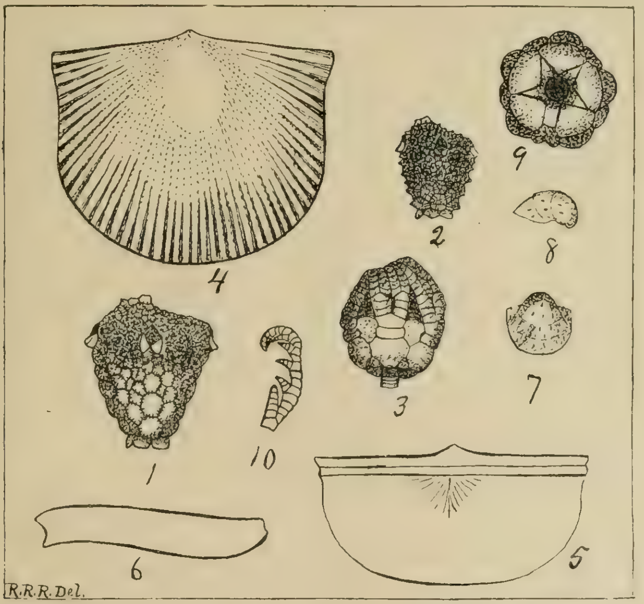
By R. R. Rowley, Louisiana, Mo.

Melocrinus tersus. (n. sp.)

Fig. 1. Side view of the body, natural size.

Calyx obconical; dome almost flat; basal plates four, three of which are quadrangular, the fourth and largest pentagonal. Breadth nearly twice the length, but slightly expanded; excavated for the reception of the column.

Of the first radials, three are heptagonal and two are hexagonal; width a little greater than length. Of the second radials two are heptagonal, two hexagonal, another? octagonal. In the ray to the left of the anal area, the second radial? is entirely separated from the first radial (a malformation) by the abutment of the lower lateral edges of the large piece of the anal area and the large interradial to the left of the anal area. Third radials heptagonal, supporting, on the upper sloping sides, two small secondary radials.



Figs. 1-10.—*Illustrations of the species described in this paper.*

Interradial areas filled by from 12 to 14 pieces, the lowest one of which is almost as large as the first radial and hexagonal. In two of the areas two plates rest on the upper sides of the first interradial and first radial, while in one area three such plates are above the first. There seem to be about ten plates in the anal interradius, but this can not be well made out from the disordered condition of the radial series to the left. All of the calyx as well as the vault plates are slightly convex but without spines and radiating ridges, except at the edges where short connecting ridges give a pitted character to the lines of union.

Vault pieces numerous. Base of proboscis medium, excentric. Base of the free rays prominent, giving an actinocrinoid look to this beautiful species. Top stem joint rather large.

Collected from the Hamilton group of Callaway Co., Mo., by Mr. D. K. Greger. Type in the author's collection. Hight of type $\frac{13}{16}$ of an inch. Width at vault $\frac{12}{16}$.

Melocrinus lylii. (n. sp.)

Fig. 2. Side view of the type, natural size.

This is the smallest crinoid yet discovered at the Callaway locality. Three of the basal plates are quadrangular and the fourth pentagonal, slightly projecting outward. Three of the first radials are heptagonal and two hexagonal; width and length about equal. Second radials hexagonal. Third radials heptagonal, supporting above two series of two small plates each. Interradial series twelve to thirteen, arranged as usual in this genus. First interradial about as large as the second radial piece and hexagonal. Anal interradius composed of twelve pieces, all being small with the exception of the lowest piece.

All the plates of the calyx of this little crinoid bear a central short spine and strong radiating ridges connecting the centers of all the plates, giving the specimen a very handsome appearance.

Vault plates numerous, almost spinose and having the radiating ridges. Proboscis slender, excentric. Free rays, arms and column unknown.

Specific name given in honor of Prof. J. N. Lyle, of Westminster College, Fulton, Mo. Collected from the Hamilton beds of Callaway Co., Mo., by Mr. D. K. Greger. Type in the author's collection. Hight of type $\frac{9}{16}$ of an inch. Width at vault $\frac{8}{16}$.

Strophonella crassa. (n. sp.)

Fig. 4. View of ventral valve, natural size.

Fig. 5, so drawn that the whole cardinal area is seen, natural size; dorsal view.

Fig. 6, showing the thickness of the shell and shape or outline, nat. size.

Shell semicircular, slightly eared at the cardinal extremities. Heavy and thick for a species of this genus. Dorsal valve slightly concave from the obsolete beak to the middle, convex beyond. Striæ numerous, rather small and indistinct on both valves, probably due in part to the state of preservation of the type. Ventral valve low-convex behind the beak, flat toward the circumference. Beak not incurved, slightly elevated, giving a wide, low, triangular cardinal area. Both valves have areas but there is no deltidium.

This species is apparently nearly related to S. reversa, but is a much larger form, with less concavity to the dorsal valve and less convexity to the ventral valve.

Collected from the Hamilton beds of Callaway Co., Mo., by Mr. D. K. Greger.

Length of the type $1\frac{1}{4}$ inches, breadth along the cardinal line $1\frac{1}{16}$.

Productella marquessi. (n. sp.)

Fig. 7. View of the ventral valve, natural size.

Fig. 8. Side view of same valve, natural size.

This small shell is sub-circular in outline. Cardinal line of a little less length than the greatest width of the shell. Ventral valve without striæ but provided with a few slender spines, convex. Beak incurved. Cardinal area very narrow, scarcely appearing more than a line. Dorsal valve deeply concave, apparently without striæ and spines. Lines of growth cross both valves.

This little Productella resembles *P. pyxidata* from the Lithographic limestone, but is much smaller and from a lower horizon. Length of type $\frac{5}{16}$, width $\frac{6}{16}$ of an inch.

Specific name given in honor of Prof. E. H. Marquess, of Westminster College.

Collected by Mr. D. K. Greger from the Hamilton beds of Callaway Co., Mo.

Taxocrinus concavus (Rowley).

Fig. 3. Base slightly turned toward the observer, showing the concavity. A specimen with arms entire and a short piece of the column. Natural size.

Fig. 9. Basal view of another specimen. Natural size.

Fig. 10. An arm of the type specimen above the second bifurcating plate, showing the short, strong pinulæ from which the hard matrix has been cleaned away. The left free ray appears much shorter than the right but probably curves sharply inward.

This species was described in the last November number of the GEOLOGIST, and is here again illustrated to show additional features.

We are well aware of the fact that pinulæ have not before been noticed in any of the genera and species of the Ichthyocrinidæ; if then what we have designated arms are really free rays, and the so-called pinulæ, arms, we have here an aberrant Onychocrinus or a new generic form.

January 24, 1894.

THE CHEMICAL COMPOSITION OF SOME OF THE WHITE LIMESTONES OF SUSSEX COUNTY, NEW JERSEY.

By FRANK L. NASON, New Brunswick, N. J.

One of the strongest objections, to the writer's view, of the contemporaneous origin of the white crystalline limestone and the blue or "magnesian limestones," has been the generally supposed fact that the white limestones are as a rule non-magnesian, while the blue limestones are magnesian. It is hardly necessary to state that the Taconic or Lower Cambrian fossils found in the blue limestones, called Calciferous or Magnesian by Dr. Cook, and in the sandstone called by the same author Potsdam (Geol. of N. J., 1868, p. 38), make this assumption much more admissible, by carrying the magnesian formation considerably downwards in the geological time scale.

During the writer's engagement with the Lehigh Zinc and Iron Company, while prospecting on the extension of the franklinite deposit at Mine hill, at Franklin Furnace, many facts came to his notice which seem to have an important bearing on this question. The general shape of the outcrop of the franklinite bed is shown in fig. 1, as well as the location of some of the bore holes. Along the line a–b, fig. 1, twenty to twenty-five feet from the franklinite bed runs a parallel bed of magnetite, from a few inches to two or three feet in thickness. The magnetite lies between the gneiss and the limestone foot wall of the franklinite bed. From this foot wall bed two samples of limestone were taken, covering a distance of about one thousand feet along the line of strike. None of the samples collected effervesced with cold hydrochloric acid.

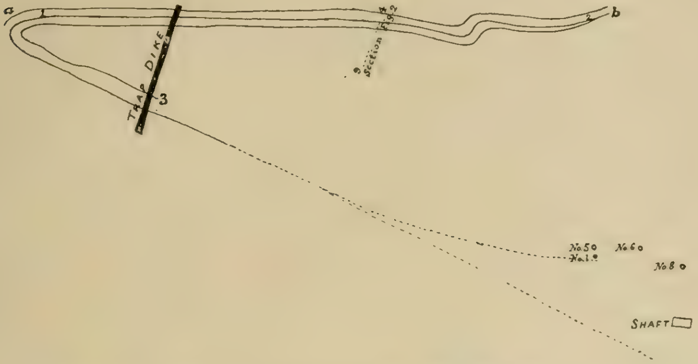


FIG. 1.—*Outcrop of the Mine hill ore body.*

1-2.—Magnesian limestone, foot wall of mine. 3.—Point where the back vein goes under ground. 3-No. 8.—Position of back vein under ground. Nos. 1, 5, 6 and 8. Diamond drill holes. 4-9. –Position of section, Fig. 2, shaft 400 feet deep. 3-*a*-*b*.—Outcrop of ore body.

Through the kindness of Prof. Smock, state geologist of New Jersey, these samples were analyzed under the supervision of Prof. A. H. Chester, official chemist of the survey. The analyses are as follows:

	I.	II.
Insoluble	0.58	5.75
$Fe_2O_3 + Al_2O_3$	1.84	1.80
Ca CO_3	62.96	51.12
Mg CO_3	31.94	40.52
Totals	97.32	99.19

These analyses show that on the surface at least there is an outcrop of white magnesian limestone, which is nearly a typical dolomite. During the month of August, 1893, some exploring work in the Trotter mine was done with a diamond drill, for the purpose of determining whether or not any lenses of ore had been left either in the foot or the hanging wall of the mine. The drill holes were bored at the four hundred foot level. Through the courtesy of Mr. J. A. Van

Mater, the mine superintendent, the writer had the borings in the foot wall continued to the gneissic rock. In fig. 2 the line a-x represents the position and direction of the drill hole. The core of the drill was preserved and tested by the writer with hydrochloric acid. The result was what was expected. Between the magnetite bed and the franklinite the core preserved was ten feet long, which is probably about one-half of the entire distance. This makes the thickness of the limestone foot wall at this point practically the same as at the surface.

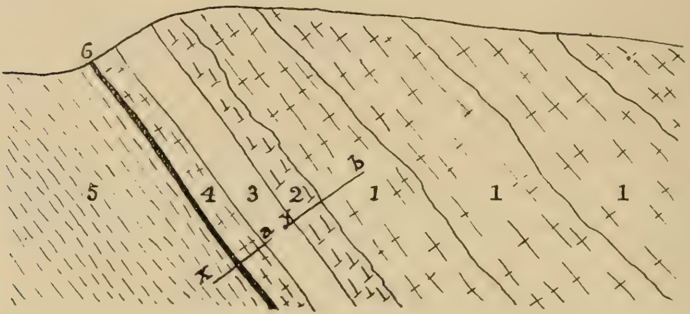


Fig. 2.—*Section through No. 4 shaft.*

1.—White dolomite, coarsely crystalline. 2.—White limestone, coarsely crystalline. 3.—Ore body, mined out. 4.—Dolomite foot wall. 6.—Magnetite bed. 5.—Gneiss.

Samples of the core were carefully selected for analysis. The result is as follows:

	III.
Insoluble	0.66
$Fe_2O_3 + Al_2O_3$	1.55
$CaCO_3$	54.31
$MgCO_3$	43.92
Total	100.44

What is more remarkable than the above is an analysis of a stratum of limestone midway between two lenses of franklinite ore. The stratum, as indicated by the drill core, is about ten feet thick, and is thickly sprinkled with crystalline grains of franklinite. An analysis gave the following result:

	III.[1]
Insoluble	0.39
$Fe_2O_3 + Al_2O_3$	4.58
$CaCO_3$	63.81
$MgCO_3$	29.82
Total	98.60

Usually the "vein matter" of the ore body is carbonate of lime, which, owing to the presence of manganese, turns black after a short exposure to the weather. It is usually free from magnesian carbonate. This is also generally true of a belt of limestone, from one to ten feet thick, on the hanging wall side of the mine.

After the bore hole in the foot wall was finished, the drill was turned into the hanging wall. See fig. 2, y-b. The drill passed through a small lens of ore and then for twenty feet into pure limstone. As before, the core was tested with acid. About two feet of the core effervesced freely, the balance did not. Samples of the part which did not effervesce were taken and analyzed, with the following result:

	IV.
Insoluble	10.28
$Fe_2O_3+Al_2O_3$	2.25
$CaCO_3$	50.82
$MgCO_3$	36.52
Total	99.87

This is again a dolomite. It is especially interesting since it is found in the hanging wall less than ten feet from the ore body. The limestone is a dark bluish gray, rather than white. There is a good deal of sphalerite and pyrite in crystalline grains. The end of the core, near the point, in fig. 2, is almost a calcareous sandstone, the silica being present in clear grains. The fact that the high percentage of insoluble matter, 10.28, is due to silica, was proved by treatment with hydrofluoric acid. All was volatilized except .75.

Analyses I, II, III and III¹ show very conclusively that the outcropping magnesian limestone which forms the foot wall of the ore body, and occurs between that and the gneiss, is persistent to the depth of at least four hundred feet from the surface. Another analysis shows that this bed reaches still farther, A piece of the core from the drill hole No. 5 (see fig. 1), 1,100 and 1,111 feet from the surface, and below the ore body, gives the following:

	V.	VI.
Insoluble	0.20	0.03
$Fe_2O_3+Al_2O_3$	3.95	0.31
$CaCO_3$	55.91	93.99
$MgCO_3$	39.68	5.48
Totals	99.74	99.81

No. V shows an almost typical dolomite, No. VI only a magnesian limestone. No. V is dark bluish gray in color, while No. VI is white and sparkling. No. VI is at the bottom, nearly, of the drill hole and is in contact with granite and has spots, and, in places, crystals of chondrodite. Analysis No. V proves very conclusively the extension of the bed of crystalline dolomite from its outcrop on the front vein to a distance (east) of about 900 feet on the surface, or, following down the dip, a distance of about 1,700 feet.

On the surface, about fifteen feet back of the front vein (fig. 1, a-b), the limestone is bluish-gray and does not effervesce with acid; it is probably a true dolomite. This would indicate that the dolomitic hanging wall of the ore body is the same as that proved by the analysis (No. IV) of the drill core from the hanging wall and four hundred feet from the surface. (See fig. 2, y-b, for position of drill hole.) As a proof of the surface extension of this dolomite an analysis was made of samples taken from a large pump station cut in the shaft which is being sunk (see fig. 1). This pump station is 450 feet from the surface.

	VII.
Insoluble	0.09
$Fe_2O_3 + Al_2O_3$	0.85
$CaCO_3$	55.28
$MgCO_3$	44.51
Total	100.73

This sample is 500 feet above the ore body at this point. Since the above analysis was made, however, the shaft has been sunk to 750 feet. The material passed through was principally limestone, probably dolomite, as it did not effervesce with acid, till at about a depth of 700 feet a sparkling, white limestone was reached, which showed a brisk effervescence. This limestone was two feet thick and lay upon a granite dike twelve feet thick. Below the dike for thirty-six feet, the present depth, the limestone is very coarsely crystalline, the crystals of calcite being often six inches across. Above and below the dike the effervescing limestone, probably non-magnesian, is thickly studded with clusters and bands of bright crystalline masses of chondrodite, phlogopite (decomposed by sulphuric acid), and tremolite. Above 450 feet, to the surface, the principal part of the limestone was a dark, bluish gray to a dirty white color, all non-effervescing except with hot acid. In consideration of this behavior it is, without doubt, of the same composition as the dolomite in analysis No. VII. There were two or three granite dikes encountered within this distance of 450 feet and on either side of these dikes the limestone was white, sparkling and filled with the minerals above named.

The above analyses seem to be a clear demonstration of the fact that the franklinite ore body lies in a magnesian limestone, in fact a true dolomite, except the instances named, when the limestone came in contact with granite dikes; second, that the white limestone is generally non-magnesian *only* when in close contact with granite or some other eruptive rock. This last conclusion has been stated in advance of many facts supporting it. The latter facts have been observed on the surface at surface contacts alone, but this one fact stands out very clearly, that in the shaft and in the drill cores the magnesian limestone extends through the whole thickness of the formation. When non-magnesian limestone occurs, it is in connection with granite, which may or may not appear on the surface. There may be some exceptions to this rule, for the writer was not present during the sinking of the shaft. The difference in the color of the magnesian and non-magnesian limestone is so great, however, as to be noted by the men. Mr. Van Mater has observed this relation, that is, between the white chondroditic limestone and granite. Furthermore, the writer has observed on the dump from the shaft that when granite comes to the surface it is accompanied by non-magnesian limestone; at other times only the other variety is noted.

About 1,000 feet south of the southwest opening (see fig. 1, a) is what is known as the furnace quarry. This quarry supplies the blast furnace with flux. It is a very sparkling, white limestone, for the most part, and has a great deal of chondrodite, tourmaline and other minerals present. There is considerable tremolite present, but it is in small crystals and is not readily observed. Through the center of this quarry runs a great dike of allanite granite. Its eruptive nature is clearly shown by its numerous adventitious dikes reaching out into the limestone, by the much more coarsely crystalline texture of the limestone in immediate contact and by the contact minerals developed. At the south end of the quarry, about one hundred feet from the dike, is a bed of non-effervescing limestone about forty feet thick. Its chemical composition is as follows:

	VIII.
Insoluble	0.07
$Fe_2O_3 + Al_2O_3$	1.15
$CaCO_3$	55.28
$MgCO_3$	44.24
Total	100.74

There can be no doubt as to the dolomitic nature of this rock.

There is a still more striking fact to be noted in this connection. On a small knob, 1,980 feet almost directly east of bore hole No. 8 (see fig. 1), is an outcrop of granite. At this point the white limestone is seen in direct contact with the granite. Within fifty feet to the east of this the blue unchanged limestone is seen outcropping. Between these two points there is thirty feet which is concealed by soil. At various points along the strike of the limestone are to be observed numerous small outcrops of limestone in every degree of transition from the unchanged blue to the white. Absolute continuity was not visible. To settle the question of continuity a trench was dug across the strike, exposing a continuous series. As was expected, the rock exposure showed a progressive transition through almost every shade of color from the blue limestone to the coarsely crystalline snowy white.

The first change was that the blue limestone was broken into closely adhering prismatic fragments, showing light irregular or mottled streaks with cloudy blue aggregates. Next, the limestone showed evidences of strong compression with pressure planes developed. Along these planes, through which the rock split easily, were cloudy carbonaceous bands, with the rock a lighter color. Then the bands became more pronounced with occasional crystalline scales of graphite. Then, next, the bands became yet more distinct, and the black earthy bands of carbon were changed to bright welts of crystalline graphite. The pressure planes were still strongly developed. Finally, within six feet of the granite, the pressure planes became less apparent, and coarse crystals of limestone, with scales of graphite, chondrodite and other minerals, were abundantly developed.

As nearly as possible, the outcrop was divided into bands corresponding to the degrees of metamorphism and carefully

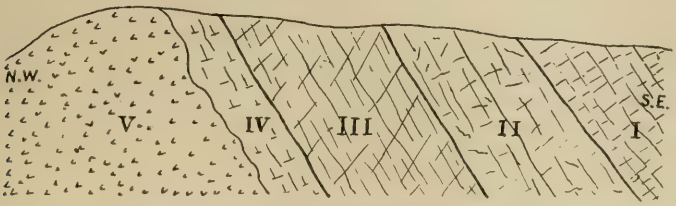


FIG. 3.—*Section through trench.*

I.—Unchanged blue limestone. II.—Prismatic slaty limestone, partly changed, with cloudy carbon. III.—Slaty limestone, very dense and compact; bright graphite scales, well crystallized. IV.—Coarse, graphitic (with slaty cleavage), chondroditic limestone, in contact with granite. V.—Granite. Distance from I to IV, forty feet.

sampled (see fig. 3, I, II, III and IV). The results of these analyses, though not as conclusive as might be wished, not showing a gradual loss of magnesia, were as follows:

	1.	2.	3.	4.
Insoluble........	7.24	7.49	11.17	1.50
Ca CO_3	71.58	49.78	56.23	96.74
Mg CO_3	19.46	39.08	31.16	1.39
Totals	98.28	96.35	98.56	99.63

No. 1 here is the unchanged blue limestone, No. 4 the limestone in contact with the granite.

Two things are to be especially noted in this connection. In the first place, though there is not a continuous outcrop from No. 8 bore hole to this point, a swamp intervening, yet at numerous places there are jagged points of limestone, north and south of this line and within two hundred feet of it. These points of rock were tested on fresh surfaces with hydrochloric acid and none of them effervesced. It seems, therefore, a tolerably safe conclusion to draw that a practically continuous outcrop across the strike of the rocks, from the foot wall of the franklinite bed to a point where the white limestone grades into the blue, is, with exceptions noted, a true dolomite, differing in no essential respect from the blue magnesian limestone.

A second fact, strongly corroborative of the above, is that in the section in figure 3 is the blue limestone in which *Obo-*

lella crassa was found, east of the southwest opening and near the Furnace pond. Along this line of strike, for a distance of nearly one mile, the transition from blue to white limestone may be noted at points where the rocks are bare of soil.

This line of transition can be traced at intervals onward for a distance of eight miles. Sometimes the transition is as above described, at others the meeting point of the two lines is marked by a brecciated zone where the fragments are more or less metamorphosed. One of these localities is to be noted by the roadside just east of Hardystonville hotel and in front of a small house. In front of the hotel, in the bed of a brook, the same brecciation may be observed. Near by is the blue limestone, and in the decomposed sandstone were found burrows of *Scolithus* and heads of the *Olenellus*, with the head plates replaced more or less completely by graphite.

From the first of the above mentioned localities a selection of specimens for analysis was made.*

	5.	6.	7.	8.	9.	10.
Insoluble....	0.81	0.04	0.88	1.24	10.92	0.50
Ca CO_3	55.62	99.05	57.58	55.72	48.13	56.05
Mg CO_3	35.52	2.00	27.18	44.62	20.34	35.34
Totals...	91.95	101.09	85.64	101.58	79.39	91.89

Specimen No. 5 is from a banded, ribbon structure, blue limestone fragment.

No. 6, a bluish gray fragment.
" 7, coarsely crystalline interstitial matter, graphitic.
" 8, coarse white graphitic limestone.
" 9, " bluish " "
" 10 is a white graphitic limestone from a point about 1,000 feet north of bore hole No. 8 (fig. 1). Nos. 6, 7, 8 and 9 were from breccia.

Two other localities where this transition has been observed were carefully sampled and tested with acid alone. One of these localities, a very prominent hill one mile east of McAfee station, shows a breccia much more striking than the place last named. Here only the limestone in direct contact with the granite showed effervescence; but after passing eastward fifty feet from the brecciated zone, unchanged blue limestone is found which extends unbroken into New York state.

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* These analyses were hastily made for the purpose of determining the magnesia, by the chemist of the Lehigh Zinc and Iron Co.

There are many other localities which could be mentioned, but instances would only be multiplied.

Southward from Mine hill the writer has found nothing which could be called transition zones, nor have samples been collected for analysis. Frequent tests were made with acid, and both the limestones were found under the same conditions.

In the "Geology of New Jersey," 1868, pp. 401 and 402, Dr. Geo. H. Cook has given several analyses of the extension of this same formation to Sparta, six miles south of Franklin Furnace.

	a.	b.	c.
Lime	51.07	28.31	29.68
Magnesia	3.02	18.04	20.07
Carbonic acid	47.47	42.08	45.51

As only the relative proportions of lime and magnesia are essential the analyses are not quoted in full.

a, crystalline white limestone, Sussex lead mine.
b, " " " Sparta.
c, " " " Ogdensburgh.

The exact localities of the first two are unknown. No. c is, however, known exactly. At the Stirling hill mines a tunnel has been driven into the hill to intersect the zinc bed. This specimen is taken from this tunnel. It is highly interesting, since it shows that the zinc deposit at Stirling hill has a dolomitic limestone for its country rock, in part at least, as well as a nearly similar deposit at Mine hill.

Though there are analyses which show, according to Dr. Cook, still smaller percentages of magnesia, it seems as if the point is well established that the white limestones are generally dolomitic, and are, excepting under peculiar circumstances, but slightly magnesian, and that, whatever argument may be brought up in the future against the writer's views of a contemporaneous origin, this point cannot be urged against them.

It is but simple justice both to Dr. Cook and to Prof. Smock, so long a time his assistant, to say that they were well aware of the problems connected with the white limestones of Sussex county. In a recent conversation with Prof. Smock, he said that both he and Dr. Cook had visited many of the localities named by the writer, and on the ground had discussed the question of transition and chemical composition; and that at one time they had considered the possibility of making a division between the magnesian and the non-magnesian white limestones. When, however, the attempt was made, the difficulties of the problem became so great that in the press of other work the subject was dropped.

A BIT OF IRON RANGE HISTORY.

By HORACE V. WINCHELL, F. G. S. A., Minneapolis, Minn.

The average mining man has but little respect for the science of geology. He looks upon it as something purely theoretical, while the discovery, development and exploitation of mines he considers simply and purely practical. He regards with distrust the opinion of every man who professes himself a geologist; but is ready to put a large share of his fortune into a venture of any one who claims to have been for years a "practical miner."

The miner himself is no less prejudiced against the student of rocks. Many are the tales told in all mining camps of the ignorance and errors of the geologists who have visited the region. It has been the writer's fortune to hear several of these yarns—the cloth for which was woven on the spot out of a tissue of absurdities—told about himself. Because a geologist visits a certain mine but once or twice the miners at that place conclude that that is the extent of his acquaintance with mines; and ignorant of the weeks and months devoted to field investigation by this same geologist, and the exact habits of observation acquired by careful training and his years of research into the literature of ore deposits, they set him down as a recluse with his mind full of "book-learning" and ideas that do not in the slightest degree harmonize with the facts as the miner finds them.

The cause of this prejudice is partly excusable ignorance, and partly wilful neglect of opportunities of becoming acquainted with the real intent and content of geological knowledge. Your average miner would scorn to read a geological treatise upon the very mine or district in which he is employed or has a proprietary interest.

The result is twofold. The first, and by far the most im-

Correction: Through inadvertence the quotation on page 167 from the "Report of the Commissioners of the Geological Survey" of Wisconsin was inserted in the account of the Penokee-Gogebic range. It evidently refers to the Menominee range, and should be so interpreted.

portant, consequences fall upon the miner and mine owner himself. In the first place he does not discover his hidden wealth so soon as he would if he read understandingly the geological reports of his region. In the second place he wastes his money in developing his mine. These statements are not made ill-advisedly. Many such instances have come under the writer's personal observation. The money that is wasted in every new mining district, simply because of ignorance of its geology, would purchase several of the best mines subsequently developed there.

The second result affects the geologist. He does not receive the credit which is his due for the work which he may have performed years before in unraveling the tangled geological history of the district in question. Perhaps the very mode of deposition and manner of occurrence of the ores was pointed out, in plain language, and their discovery announced or predicted in that identical locality. Nevertheless, when at some later period these discoveries are accidentally confirmed or made as predicted, the poor geologist is forgotten or misrepresented by the declaration that "he always said there was no ore there and discouraged exploration." And the miners have forthwith another instance of the worthlessness of geological investigation.

Although not original nor the first time dwelt upon, these reflections arise with renewed force on reading the recent articles in the *Engineering Magazine* on the "Iron Ore-Region of Lake Superior," by Mr. R. A. Parker of Marquette. "Vanity of vanities, all is vanity," may well be the wail of any geological prophet who expects to receive honor in his own country. For here again comes one who should be posted on such matters, and professes to give a historical and descriptive sketch of the discovery and development of these iron ore ranges, and yet we find the same old story of "rumors [in 1883] of the occurrence of soft red hematite" and "the discovery of ore beneath the roots of a tree" on the Penokee-Gogebic range. Furthermore, the Vermilion range is said to have been found in 1875 by explorers, and of the Mesabi* it is said "discouraging reports of the district had been given by explorers and geologists," but "by perseverance the ore was found." As the result the reader is left with the impression that no real assistance was ever rendered by geologists in the discovery of these valuable ore deposits; that all the geological surveys that had been prosecuted in these districts prior to 1883, 1875 and 1891, respectively, failed to find and report the indications of ore, or else reported unfavorably; in short, that one man is just as likely to discover mineral treasures as another; that ignorance is as desirable as knowledge, and it is all a matter of chance anyhow.

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*This is the spelling adopted by the National Geographic Society, the U. S. Geological Survey and the Minnesota Geological Survey. It has been used on all authoritative maps since 1866.

What were the real facts in the matter? Were these three iron ranges visited and studied and reported on favorably or unfavorably by geologists prior to the "discoveries" of ore mentioned by Mr. Parker?

PENOKEE-GOGEBIC RANGE.

In D. D. Owen's "Report of a Geological Survey of Wisconsin, Iowa and Minnesota" there is a "Geological Report of that portion of Wisconsin bordering on the South Shore of Lake Superior, surveyed in the year 1849," by Charles Whittlesey. On pages 444-447 of this report (published in 1852) is a description of the "Magnetic Iron-Beds of the Penokie Range." Analyses of iron ore found there are quoted which show from 56.3 per cent. to 66 per cent. of metallic iron, and the following statements are made:

> The bed of magnetic iron ore south of Lac des Anglais is of extraordinary thickness,—twenty-five to sixty feet. * * * * In the wild and deep ravines where the Bad river breaks through the range, there is a cliff of slaty ore, most of which comes out in thin, oblique prisms, with well-defined angles and straight edges, probably three hundred feet thick, including what is covered by the talus or fallen portions. I estimate more than one-half of this face to be ore; and in places the beds are from ten to twelve feet in thickness, with very little intermixture of quartz. There are portions of it not slaty, but thick-bedded.

The geological occurrence is fully figured and described, and the similarity of this ore to "the extensive mines or rather mountains of iron ore in Michigan, described by Houghton, Burt, Jackson, Foster and Whitney" is also mentioned. The idea of exploitation on a large scale is conveyed in the last paragraph:

> The position of the best exposures of ore which I saw is such as to require from eighteen to twenty-eight miles of transportation to reach the lake. The nearest natural harbor is in Chegwomigon bay, about twenty-five miles from the central part of the Penokie range.

In the "Report of the Commisssoners of the Geological Survey" of Wisconsin for 1858 are the following remarks by the same writer:

> In 1850 I passed up the Menomonee as far as Irwin falls, and examined the rocks to the east of the river in Michigan. Here the magnetic and specular ores were found, and beautifully veined marbles. The system of Magnesian slates extending from Carp river, on lake Superior, westward and southwestward, which embraces the metamorphic limestones and the iron, was then traced to the state line of Wisconsin.
>
> During the explorations of the present year, in tracing that system within this state across the Menomonee river, I had the satisfaction to find that it produces here both iron and marble, in quantities that are inexhaustible.
>
> I cannot in this note, nor until the analyses are completed, give an idea of the value of the ores, but I am satisfied that whenever a cheap mode of transportation is provided, they will attract notice. Both the iron ores and the marbles exist on both sides of the river convenient to water power that is unlimited. A considerable part of the deposits of iron have hard wood near at hand suitable for coal.

The interesting origin of the name "Penokie" was given as follows by Col. Whittlesey in an article on "The Penokee Mineral Range" read before the Boston Society of Natural History in July, 1863:

> In the Chippeway language the name for iron is *pewabik*; and I thought it proper to designate the mountains, where this metal exists in quantities that surprise all observers, as the "Pewabik Range." The compositor, however, transformed it to *Penokie*, a word which belongs to no language, but which is now too well fastened upon the range by usage to be changed.
>
> Soon after the publication of Dr. Owen's report, the excitement of 1845-6 in reference to copper was repeated in reference to iron. Preemptors followed the surveyors, erecting their rude cabins on each quarter-section between the meridian and Lac des Anglais, a distance of eighteen or twenty miles. The iron belt is generally less than one-fourth of a mile in width, regularly stratified, dipping to the northwest conformable to the formations, and having its outcrop along the summit of the second or southerly range.

So much iron was found there that he intended to call it the "Pewabik" range in 1850, even before the government survey of the region.

This paper was accompanied by a geological map of the range prepared by Whittlesey in 1860, on which the crest of the range and the outcrops of iron ore are marked with wonderful accuracy.

But Whittlesey was not the only geologist who observed and described the mineral wealth of this region. In 1858 Edward Daniels, one of the State Geological Commission, and prior to that time State Geologist, visited the Penokee-Gogebic range and mentions it as follows in the Commissioner's report for 1858, pp. 10, 11:

> The mineral resources also promise richly. The most important of these are the great deposits of iron ore found in the Penokie Mountains, about thirty miles inland from the head of Chegwomigon Bay. These iron beds follow the mountain ridge through several townships, having a direction a little North of East. * * * * The ore is principally the magnetic and brown oxide, with traces of specular iron, and occurs in seams parallel with the stratification, varying from a mere line to fifty feet in thickness; it is of good quality, well located for quarrying, and practically inexhaustible.

Another well-known scientist who saw and appreciated the ore deposits of this range was Dr. I. A. Lapham, afterward State Geologist of Wisconsin. He visited the Penokee district with Daniels in 1858. His account of the trip may be seen in the Trans. Wisconsin State Agricultural Society, Vol. V, 1858-59. He there gives what is perhaps the first published map of the range, and speaks highly of the iron ore he saw there. In a report made by Dr. Lapham to the Wisconsin and Lake Superior Mining and Smelting Company, dated November, 1858, and published in pamphlet form in 1860, we find the following:

> It will be seen that we have already discovered good ore in such quantities as to be practically inexhaustible, situated at points accessible to water power and having bold fronts, rendering it comparatively easy to be quarried. For many years to come only the richest and most accessible ores can be brought into use, rejecting—at least for the present—all such as have too large a proportion of silica, and such as are not in a condition to be easily and cheaply removed from the natural bed.

Further full accounts of the Penokee-Gogebic range are to be found in Volume III of the Wisconsin Geological Reports for 1873-79, pages 100-166.

MINNESOTA IRON RANGES.

In Minnesota we find a similar çondition of affairs. The first account of iron ore on the Vermilion range appears to be in the report of State Geologist H. H. Eames, published in 1866. On page 11 is this account:

> THE IRON RANGE OF LAKE VERMILION
>
> Is on the east end, on the stream known as Two River. which is about sixty feet wide. * * * This range is about one mile in length, it then ceases. and after passing through a swamp, another uplift is reached, from two hundred and fifty to three hundred feet high. The iron is exposed at two or three points between fifty and sixty feet in thickness, at these points it presents quite a mural face, but below it is covered with detritus of the over-capping rock. On this account its exact thickness could not be correctly ascertained. The ore is of the variety known as hematite and white steely iron, and is associated with quartzose, jasperoids and serpentine rocks. It generally has a cap rock of from three to twenty feet thick. A little to the north of this is an exposure of magnetic iron of very good quality, forming a hill parallel with the one described.
>
> The hematitic iron has a reddish appearance from exposure to atmospheric influence; its fracture is massive and granular, color a dark steel gray. The magnetic iron ore is strongly attracted by the magnet and has polarity, is granularly massive, color iron black.

At the request of the legislature of Minnesota Col. Charles Whittlesey made a "Report of Explorations in the Mineral Regions of Minnesota during the years 1848, 1859 and 1864," published in Cleveland in 1866. In this report is a map of Vermilion Lake and the Mesabi Iron Range. It also contains, on page 10, an announcement of the discovery of iron ore at the former locality by Eames. Here Col. Whittlesey gives it as his opinion that workable iron ore exists near enough to lake Superior to render it of practical value.

The original discovery of iron ore on the Mesabi range must also be credited to Mr. Eames. In his report of 1866, published the following year, is an account of the occurrence of iron ore on the western end of the range, at Prairie river, and several analyses are given, showing it to be of good quality. Favorable mention is also made of the Mesabi in various other geological reports between that time and 1891. It will be sufficient to call attention to the views advanced in Bulletin No. 6 (written in 1890; published in 1891) of the Minnesota Survey, where a detailed account of the range is given and it is stated (pages 112 and 160):

> They [the ores of the Mesabi] are destined to play a very important part in the future development of the iron industry of the state. They occupy fourfold the area that is occupied by the Keewatin ores [Ver-

milion range], and they are nearer the ore-shipping points as well as the iron-using markets. It is on account of this high promise of future productiveness that they are fully described in this bulletin. * * *

There can be no reasonable doubt that in Minnesota, about the western and northwestern confines of the lake Superior basin and extending westward to the Mississippi river, there will yet be mined in the Mesabi range even greater quantities of hematite than have been taken from that marvel of mining districts, the Penokee-Gogebic range which blazed out with such a brilliant record only a few years ago.

The above quotations are sufficient to establish the following points: (1) The ore on these three ranges was found by geologists who published accounts of their discoveries; and all reports to the contrary are but idle tales. (2) The accuracy and trustworthiness of those early reports has been fully demonstrated by subsequent developments. (3) Had the mining public given due credence to those reports it might have reaped the benefit from them a quarter of a century sooner than it did.

If this article had been written in a spirit of criticism rather than for the purpose of setting forth a few historical facts that were in danger of being forgotten, there are many careless statements in the magazine articles above referred to which would have called for correction. They are but minor points, however, and the present writer will be well satisfied if he has been able to dissipate any of the cloudiness that now surrounds the history of our iron districts, and to aid in the firmer establishment of the truth.

PLEISTOCENE HISTORY OF THE CHAMPLAIN VALLEY.

By S. Prentiss Baldwin, Cleveland, Ohio.

(Plate V.)

More than thirty years ago Prof. C. H. Hitchcock gave a careful description and map of the surface geology of the Champlain valley.* The Champlain clays were mapped and their marine origin was pointed out; and they were subdivided into the deeper "blue clays" and upper "brown clays," the former characterized by *Leda portlandica* (*Yoldia arctica* Gray), the latter by *Macoma fusca*, (*M. grœnlandica* Beck),

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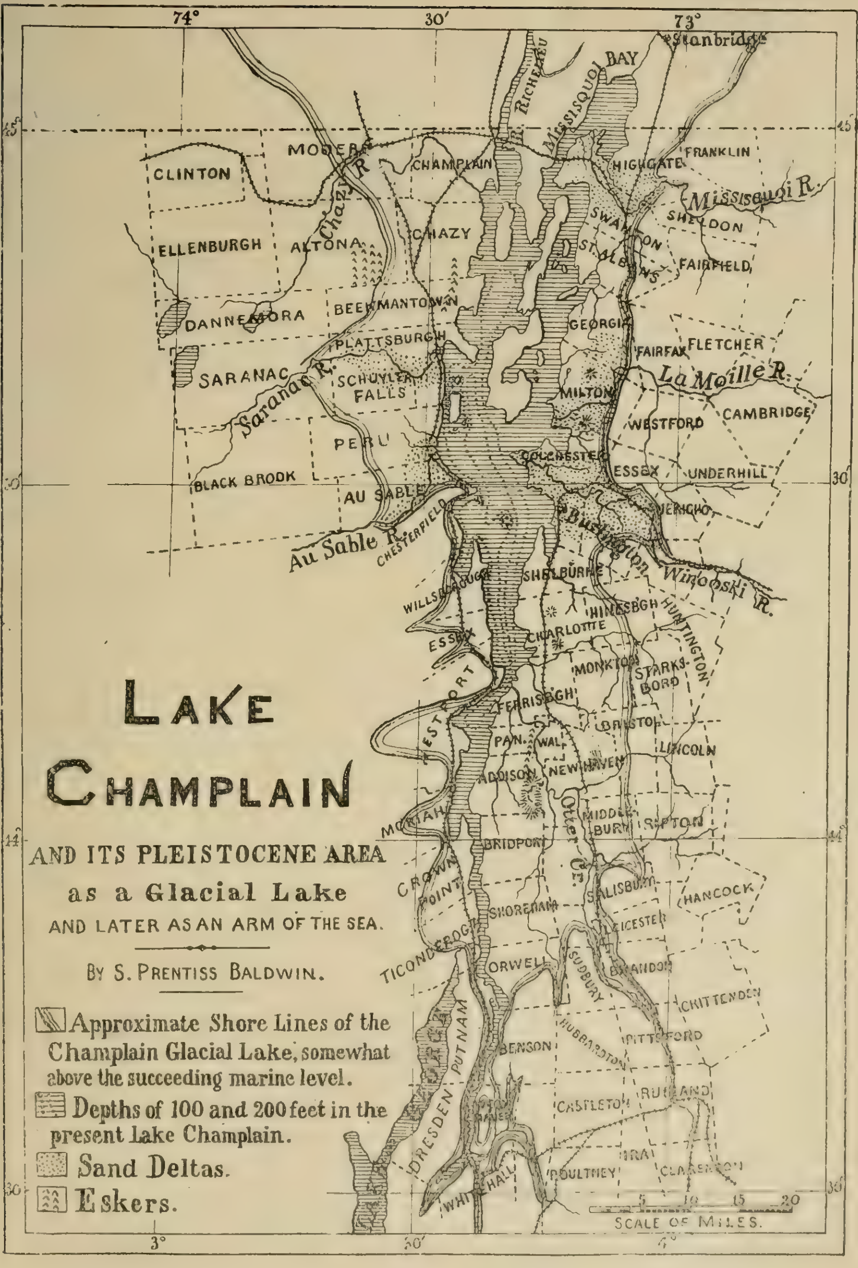
*Geology of Vermont, 1861, vol. i, pp. 93-167, with map.



LAKE CHAMPLAIN

AND ITS PLEISTOCENE AREA
as a Glacial Lake
AND LATER AS AN ARM OF THE SEA.

BY S. PRENTISS BALDWIN.

▨ Approximate Shore Lines of the Champlain Glacial Lake, somewhat above the succeeding marine level.

▤ Depths of 100 and 200 feet in the present Lake Champlain.

▒ Sand Deltas.

⩓ Eskers.

five to ten-miles from the lake. The townships between the high levels and the lake form one great clay plain, extending as far as the Winooski sand delta near Burlington, broken only here and there by small hills rising abruptly from the plain, somewhat resembling, in appearance, the region of buried mountains in Nevada, but on a smaller scale. A definite ancient water level seems to be traceable in Orwell at 410 feet. East of Middlebury village a long sand plain has a hight of 460 feet, with such well defined level that one readily applies the term "islands" to the occasional hills which rise above it. Yet it is doubtful if the clay deposits reach the town of Middlebury at 390 feet. The shore townships, Addison, Panton, Ferrisburgh, Charlotte, and Shelburne, exhibit a decided contrast to the higher townships, as Middlebury and Bristol, where the glacial surface deposits are scarcely concealed by the later lacustrine and marine deposits. Passing inland from the shore, the clays rise in broad terraces, often nearly a mile across and each terrace usually from 30 to 50 feet above the one below, yet we were unable to connect the terraces of succeeding townships into continuous levels.

A well defined esker runs through East Panton and Addison, from Vergennes to Snake mountain, rising about 150 feet above the plain and sloping steadily to the south. It rises above the clays, but is partly buried in them. On the west side of this esker in East Panton is Elgin spring, the most southerly point from which marine shells had been reported.* We visited the spring, but did not succeed in finding any shells, nor could we get any information of them from the residents of the vicinity, so we could not verify the report. The clays clearly extend to 250 feet, and probably the marine levels reached 350 feet. Marine shells appear at Vergennes at nearly 250 feet, while at less than 150 feet shells may be found in the brown clays at almost any point from central Addison north. Faint lines seem to have been cut in the till of Snake mountain to a hight of 586 feet. Such a level would almost completely cover all the shore townships. But the more decided levels up to 350 feet would leave Snake mountain, as well as several hills in Waltham, Monkton, and Ferrisburgh, above the water as islands.

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*Geology of Vermont, vol. i, p. 159.

In Charlotte, Mt. Philo and Mutton and Pease hills are surrounded by sand terraces at hights of 415 and 450 feet. Between Mutton hill and the shore are three parallel ridges of the same hight, 150 feet each, and standing about 30 feet above the plain, about a mile apart. No sections of these ridges could be found, but they seem to be sandy beaches, made to appear higher above the plain than they originally were, from the fact that the present streams have eroded the plain between them at least 15 feet. From Mutton hill east to central Hinesburgh the plain is cut by brooks flowing north to Shelburne bay, and on either side of each brook are broad sand terraces, three or four in number. The sand terraces of these brooks contain marine shells in Shelburne, as at Morse's and Shelburne Falls. The lower sand terraces along the brooks undoubtedly come from the re-washing of the higher terraces, as the water fell to lower and lower levels. This is shown by the condition of the shells, which are generally in place in the clays, with valves together and very little broken, while in the sands of the lower stream terraces they are broken and separated. Shells are plowed up and dug up in post-holes at any point between Mutton hill and the shore, and they are said to occur in beds 4 or 5 inches thick, a little below the surface. The discovery of the bones of a whale (*Beluga vermontana* Thompson*) in the clays of this plain, together with shells of *Saxicava* and *Macoma*, in 1849, was fully described in the Vermont report,† and needs no further mention.

The township of Shelburne closely resembles Charlotte, one general clay level, broken here and there by outcrops of rock above that level; each outcrop shows evidence of having been an island, while the water held successively lower levels, by a series of encircling terraces. At Shelburne Falls and again at Morse's, near the railroad, are stratified sand deposits, containing *Macoma fusca*, at 180 feet. In the north part of Shelburne, near the township line, one mile east of Gov. Barstow's, shells, which from description seem to be *Macoma*, are said to be plowed up at 400 feet. At this point a marble out-

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*Regarded by Sir J. William Dawson as the same with *B. catodon*, which is now frequent in the estuarine lower part of the St. Lawrence. (Canadian Ice Age, p. 268.)

†Vol. i, pp. 162-5.

crop seems to be surrounded by a faint terrace. The marine limit may have come to this hight, but certainly went no higher. The clays are not noticeable above 285 feet.

Winooski Delta. Coming to Burlington, we find increasing sand terraces and much less clay, marking the approach to the Winooski delta. Just outside the city of Burlington are very distinct terraces to a hight of 330 feet. Beneath the sand of the lower terraces the clays appear, bearing shells. The Winooski delta is composed almost entirely of light, stratified sands, covering the north part of Burlington and Williston, Colchester to Mallett's bay, and the southwestern part of Essex, then narrowing to the river valley as the higher levels of the foot-hills of the Green mountains are reached. Thence river terraces, four or five in number, mainly of sand, extend up the river beyond Middlesex. The hight of this sand plain near Essex Junction is about 340 feet, the terrace No. 4 of the Vermont report,* while the next marked terrace, below that, is very distinct at 215 feet. The blue clay lies at nearly the same general hight under the lower end of this delta as in Charlotte, and it furnishes a very good brick clay north of Winooski Falls. As there seems to be no rock near the surface through the greater part of the area of the delta in Colchester and Burlington, the Vermont report suggests that the river filled up a considerable area between Colchester point, then an island, and the main shore, thus connecting it with the mainland.† This seems entirely probable.

La Moille Delta. The La Moille formed a large delta‡ very similar to the Winooski, making up a great share of Milton, southern Georgia, and northern Colchester, of two distinct levels, 270 feet and 400 feet, following up the river in terraces as on the Winooski. Snake and Cobble hills stood as islands at the highest extent of the lake, and show very distinct terraces to 450 feet. In this vicinity are two interesting shell deposits. On the south shore of Mallett's bay a bank of stratified sands and clays is cut down by the road to expose a fine bed of *Saxicava*, with a few *Macoma* shells, both in good state of preservation, and, in nearly every case, with the two valves together; the *Saxicavas* usually standing upright in their bore-holes in the clay. Again, in West Milton, a short distance east of A. A. Herrick's, the sand terrace of the 270 feet level is cut to a depth of 70 feet, exhibiting a sand and clay deposit containing *Saxicava* and *Macoma* and exposing toward the head many large and finely glaciated boulders. Unfortunately we could not find an exposure of the undisturbed strata, to discover the exact relations of the deposits; but, from the distribution of the boulders, it is probable that here is an esker or kame of about the same hight as the exposed esker in Panton, but the still higher sands of the delta cover this one. At Checkerberry Village, on this delta terrace at 270 feet, we were informed that *Saxicava* and *Macoma* can be found in almost any excavation, a few feet below the surface.

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*Vol. i, p. 132.

†Ibid.

‡Ibid., p. 142.

The next large delta is that of the Missisquoi,* covering with sand a large part of northern Swanton, southern Highgate, and Hog island, the last being just at the flood level of the present lake.

From here north the higher levels are far back from the lake, and the Champlain valley opens into a great clay plain, which stretches out 25 or 30 miles on either side from the Richelieu river, north of Missisquoi bay, and which probably extends to Montreal and the St. Lawrence. I have not traversed it. Little or no rock is exposed anywhere in this plain. The surface of this plain is ribbed at distances of half a mile or so with beaches, which stand about 15 feet above the general level. Probably no part of the plain is more than 150 to 200 feet above the sea.

NEW YORK.

Whitehall to the Au Sable. On the west side the highest levels are found near the lake in Washington county, but from Ticonderoga to Crown Point distinct terraces extend to 225 feet. It is not probable that the marine terraces extend to lake George, though there seems to be a decided terrace at 370 feet at the south end of that lake. The lake itself is 320 feet above the sea, and the fainter glacial lacustrine levels may extend above this hight.

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*Geology of Vermont, vol. i, p. 145. This report seems to apply the term "delta" only to the deltas formed at the present lake level, while I have applied it to those deposits which were formed as true deltas at the higher levels, and pass over the present deltas as not pertinent to this discussion.

About four miles south of the village of Crown Point is a high terrace standing well above the surrounding plain, before the mouth of a small valley, and so distinct as to easily attract attention. No clear exposure of its material could be found, but it seemed to consist of drift, almost entirely unmodified. The top is perhaps half a mile broad and two miles long and pitted throughout with small kettle-holes, twenty to fifty feet in diameter. It is about 560 feet above the sea. I regard this as a typical *moraine terrace*,* formed against the ice, when it stood at that hight, by the combined action of the ice, in melting and depositing, and of a stream from the small valley which opens into it. The main deposit was from the ice, not levelled by standing water, but by action of the small stream. If that be true, the water levels are later than this terrace, and, in fact, faint lower terraces are cut on its sides.

Until Clinton county is reached, the old shore lines are nowhere far from the present lake. In Chesterfield, near Owen Ryan's, the finest beaches were seen, and on an abrupt shore. At present water level, in a small cove between the rocky points, is the first pebbly beach; above this in the same cove are three exactly similar beaches at 290, 335 and 365 feet; there the rocks disappear in two distinct terraces at 386 and 423 feet, only to re-appear above and yield three more pebbly beaches up to 550 feet. A mile or two north distinct terraces appear at 470 and 530 feet.

Clinton County. On reaching the Au Sable river the higher levels are found back six or seven miles from the lake, while the lower levels are formed of the sand delta of the Au Sable. The upper limit was not measured, but the second level is at 230 feet, corresponding well with the second level on the Winooski. The plain from here north is similar to that of the Vermont side, a clay plain, crossed by the two sand deltas of the Au Sable and Saranac. The sand banks on the south side of this delta, near Port Kent, are said to contain many marine shells.

The Saranac river is simply a repetition of the Au Sable,

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*The so-called "moraine terraces" of the Geology of Vermont are abundantly indented with kettle-holes.

Winooski and other rivers, in its large sand delta and terraces extending far up the river, covering northern Schuyler and southern Plattsburgh, and in the gorge or rapids of its post-glacial channel. One definite level of this delta is at 445 feet. The highest terrace here is at 561 feet. The change from the high glaciated region to the lacustrine and marine area is very well marked by the disappearance of kames and kettle-holes, and by prevailing shore levels and terraces, and in descending to the present lake at least ten distinct terraces may be seen.

The blue clay appears under the township of Plattsburgh bearing marine shells, in a bed five inches thick, at its junction with the sands above, and they may be found almost anywhere at 190 feet. We found these shells again at a level which Dr. D. S. Kellogg, of Plattsburgh, informs me is 346 feet. Dr. Kellogg pointed out two interesting examples of buried eskers. One of these he has carefully mapped. It is seven miles long, extending from the south part of Chazy into Beekmantown, and rises through the clays to about 60 to 80 feet above them. The other one is near Morrisonville, on the Saranac, where the road cuts a fine section through a considerable deposit of drift, which has been completely covered by the sand of the high level of the delta. This exhibits the same conditions as the esker described from West Milton, but more clearly. From Chazy the Champlain valley soon opens into the broad clay plain of the St. Lawrence.

Outlet to the North. An examination of the map (Plate V) will show that lake Champlain is largely over 200 feet deep, and in one place it reaches a depth of 400 feet, although the present mean surface of the lake is only 97 feet above mean sea level. While the uplifting of the mountains of Vermont and New York probably had much to do with the existence of a valley here, yet the valley itself is certainly a valley of erosion. Such a depth of channel below the sea level indicates a preglacial elevation for this region of more than 300 feet. But the elevation was probably very much more than that; for the depth of deposition during and since the Glacial period, and the fall necessary in order to drain this valley to the sea, must be added. This corresponds well with the depths of the larger Laurentian lakes, and of the submerged channels of the St. Lawrence, the Hudson, and other rivers.

What closed this channel? Two explanations may be given: first, warping of the earth's crust during the Ice age; second, deposition of glacial material and of the marine clays. Deformation sufficient to hold the lake at its present hight must have included a considerable and well defined uplift. If this was since the formation of the marine terraces, it must have distinctly distorted them. If it was during the Glacial period it would not probably occur until the ice had disappeared from that region, and as soon as that happened the sea came in and began building its terraces, which therefore must have been affected by the differential elevation. No evidence of such uplift was found. On the contrary, in going from south to north, the marine deposits of sands and clays evidently become much thicker, and the foot-hills on either side are more buried by them until, north of the lake, they are entirely covered by the great clay plain of the St. Lawrence. We should therefore expect this deep channel to extend under the clay plain to the north, at a depth of 400 feet or more, as a buried outlet to the St. Lawrence. My brief search revealed no evidence of importance, though it led me to believe that the outlet was not from Missisquoi bay.

THE HUDSON AND CHAMPLAIN VALLEYS.

The divide between the Pawlet river and Black creek was not examined, but seems to be a sand plain at about 400 feet.* The lowest divide is that crossed by the canal from Whitehall to Ft. Edward at 150 feet, at the same hight as the ends of the canal, Ft. Edward and Whitehall. A continuous sand plain extends from one place to the other, and is so nearly level that while the divide is really at Ft. Ann, eleven miles from Ft. Edward, yet the canal flows toward Whitehall, except the last three miles near Ft. Edward. In the town of Whitehall, the canal drops 50 feet to the level of the lake. The two valleys narrow rapidly to Ft. Ann, where is seen a typical divide between streams, entirely of rock, showing little evidence of glacial or postglacial erosion, and not at all resembling a river channel. It is not probable that any large stream ever flowed across this divide for more than a very short time, and the expression, sometimes seen, "the Hudson–Champlain valley," seems to me a misuse of terms.

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*Geology of Vermont, vol. i, p. 128.

DELTAS.

When the main preglacial stream of the Champlain valley, the Champlain river, as I shall call it, flowed in a channel 400 feet or more below the present lake surface, the mouths of its tributaries, the Winooski, La Moille, and others, must have been proportionately below their present hight. These valleys were filled up, partly with drift during the Glacial period, then with the blue clays, brown clays, and sands, during the subsequent submergence. At the mouths of the rivers, great deltas were formed which now stand not only high above the former deep channels, but high above the present channels. These tributaries now flow entirely in clay or sand beds, except here and there where they have not returned to their old valleys, but have cut small recent gorges of rock instead. The history of the delta seems to be this. The highest faint levels, which I believe to have been formed by a temporary glacial lake, were of too short duration for the accumulation of marked deltas. But on admission of the sea, the highest marine level was more permanent; the rivers were backed up as slack water far inland, and great quantities of sand and clay were washed from the glacial deposits by the flooded streams, the sand to be left along the upper part of the delta and stream, while the clays were being deposited in deeper water. Then, as the water fell from this highest marine level to the next hight, much of the highest delta sand was washed out to be spread as a second delta over the clays of the first hight, while some of this clay was in turn carried out to cover the finer clay of the deepest waters. Thus as the lake fell to lower levels, each terrace was partly cut away to form, with what fresh material was brought down, the next terrace. An interesting explanation of the derivation of the sands and clays may be seen, high above the highest terraces, at Flat Rock, Altona, N. Y., where are immense accumulations of glaciated boulders, in which is no material of even small enough size to be called gravel, the smaller material having been entirely carried away.

PREGLACIAL CHANNELS AND POSTGLACIAL GORGES.

Suppose such a high level delta formed, and that, as the lake falls, the river cuts down into the level-topped terrace. Then,

(1) it may cut back into its old channel to re-erode it, or (2) it may cut down to one side or the other of the old channel and so find rock at some point. In the latter case it may be on such a slope that it can wear away the sand on the lower side and so work back to its old channel, or it may cut into the rock and form a new channel. In that event the river will rapidly enlarge its valley where it has only to carry away the soft sands from its old bed, while the size of the new channel will depend mainly on the character of the rock through which it is cut. The rapids of the Saranac, the beautiful Au Sable chasm, and the falls of the La Moille, are probably of that origin.

On the Winooski at least two such channels may be seen from the railroad. One is about three miles below Waterbury, where the railroad passes through a part of the old channel a short distance south of the small rock gorge through which the river flows.

A better example, well worth a visit, is found just above Winooski Falls. The accompanying map requires little explanation. Standing at the quarry and looking up stream, a valley perhaps half a mile wide, limited on either side by

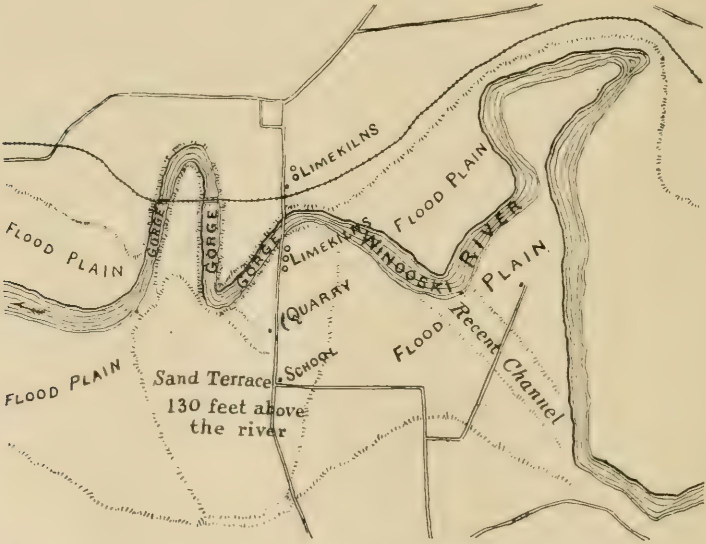

FIG. 1.—*Rock gorge near Winooski Falls, Vt.*

sand terraces, is seen, in which the river meanders through a wide flood-plain, avoiding a recently deserted channel for a long bend to the north. From the quarry north, the limestone ledge is everywhere near the surface, except for the small gorge, not more than 30 to 40 feet wide and perhaps 75 to 100 feet deep, which has been cut in the hard limestone by the present river. After a second turn south the river emerges again into the broad valley limited by sand terraces. Only a short distance south of this gorge is a sand terrace, standing exactly across the broad valley, continuous with the terraces of the south side of the valley, and containing no rock to at least the depth of the present river. The top of this terrace is lower than the top of the limestone gorge. Evidently the river has required the same time to clear out the broad valley above and the rock gorge, and both are measures of the time since the sea fell below the 240 feet level, that of the top of the terrace.

MORAINES.

Professor Hitchcock has shown that moraines of recession can be traced in the mountainous New England states, although with more difficulty than on the western plains. He alludes to a great moraine crossing Vermont from Willoughby lake, along the upper La Moille, to Burlington.* I am inclined to think that this moraine passes through Hyde Park and Cambridge to Underhill, but not to Burlington, for the buried deposits of Milton seem to indicate that it bends to the north near the lake and crosses it, to be represented in New York by the extensive deposits of Beekmantown, southern Altona, and Dannemora. Another line of exceptionally abundant drift deposition seems to pass through Ripton, also bending northward near the lake, through Middlebury and Addison. A third morainic line seems to pass just south of the lake and to continue west across the south end of Lake George.

HISTORY OF THE CHAMPLAIN VALLEY.

The Champlain River. The great depth and the form of the Champlain valley, as a valley of erosion, indicate a long continued preglacial elevation of at least 500 feet for this entire region. During that time the valley was occupied by a river far below the present lake surface; the tributary rivers occupied nearly the same valleys as now, but at greater depths, and the valley sides were uneven mountain slopes, unmarked by level plains and terraces.

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*Proc. A. A. A. S., vol. xli, for 1892, p. 175.

The Glacial period requires little comment. The entire region shows abundant evidence that it was covered by the ice, but below the high level terraces the till and striated ledges are largely concealed by the later deposits.

The Champlain Glacial Lake. Though the facts reported from the valley of the Red River of the North and from the basins of the great Laurentian lakes made it appear probable that this valley contained a glacial lake while the ice was retreating down it, I did not, at first, find direct evidence of this, but am now convinced that such a lake did exist.

Prof. J. E. Todd has briefly stated the reasons for the obscurity of shore lines of glacial lakes.* To apply them to the Champlain valley two others must be added: 1. Whatever effects the glacial lake may have left, below the later marine limit, are concealed by the heavy marine deposits; 2. The mountains on either side of the valley were probably somewhat independent centers of ice dispersion, even so late as when the ice-sheet had retreated beyond the St. Lawrence and the sea had been admitted. At any rate, the tributary streams coming from those mountains seem to have been much flooded at that time. It is necessary, in order to account for the heavy marine accumulations, to suppose either that it was a period of extensive floods, or that the marine conditions were of long duration. The effect of the floods upon the already scanty deposits of the glacial lake would be to largely remove what evidence had been left above the marine limit.

On either side of the valley, at least as far north as to Plattsburgh, strong terraces exist up to a certain hight, which, from their relations to the clay, seem to mark the marine limit, while above that level faint traces of terrace action can be found to one or two hundred feet higher. These faint terraces never show marine shells; they are usually of glaciated pebbles and cut directly from the till. These levels seldom or never appear in harder materials than till. They were of short duration.

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*Am. Geologist, vol. x, p. 299, Nov., 1892.

Another evidence of a glacial lake appears in the form of the moraines crossing the lake, if they are rightly located. I have elsewhere discussed the relation of the water front of a glacier to the land front under conditions of advance and retreat.* Evidently where no water rested against the ice-front the ice must have extended farther south in the valleys than on the highlands, and consequently the moraines crossing a valley will be convex. But the moraines crossing the Champlain valley are concave, due to rapid wasting of the retreating ice-front by the waters of a glacial lake.

During or after the greatest extent of the ice, this entire region was depressed so that since the departure of the ice the valley was occupied by the sea. The depression was greatest toward the north, the subsequent differential uplift being apparently a little over three feet to the mile. From the fact that the shores of the glacial lake seem to show the same differential uplift, it appears that the depression had reached its maximum during the existence of the glacial lake.

The marine limit barely, if at all, reached Whitehall, but the higher glacial lake probably extended across the divide and was continuous with the glacial lake of the upper Hudson, but for no great length of time. Further north, toward Plattsburgh and St. Albans, the faint action of the glacial lake can be found up to 500 or 600 feet.

The Champlain Estuary. When the ice had retreated to the St. Lawrence, the Champlain valley became occupied by the sea. The marine clays and shells prove that the sea reached the upper limit of such deposits. But the shallow water deposits of the sea must have been coarser than the clays and higher. Between the limit of clays and the faint high level terraces is a limit at 75 to 100 feet above the clays, marked by the largest and broadest terraces and the immense sand deltas of the rivers. This I believe to be the marine limit. The shells of the brown clays bear out this supposition, as the brown clays are at about the depth, below this limit, at which these marine mollusks live. Again, we must suppose that the movements of the earth's crust are slow. When this region reached its greatest depression, it did not pop up again suddenly, but must have remained at that level a considerable time. In fact, it remained there much longer than it hesitated at any one stage during its rise, for the deposits of that time are much the greatest. Besides, as by far the greatest clay deposits are marine, it is but natural to conclude that the greatest sand beds are of the same time.

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*Am. Geologist, vol: xi, p. 374, June, 1893.

At the south end of the lake this decided level is probably just at Whitehall, 150 feet, or perhaps it did not reach that place. At Plattsburgh the marine shells may be found up to 346 feet, but the high level there is somewhat over 400 feet. On the La Moille it is at 400 feet.

The marine limit reported from St. Albams is 658 feet,* but that terrace was probably formed by the glacial lake. The highest marine level there probably does not exceed 500 feet. The method pursued by Baron De Geer,† while it answers well on slopes toward the sea, is faulty when applied to such an enclosed valley, since it fails to discriminate between the *marine* limit and the *glacial lake* limit.

I have constantly referred to terraces, rather than beaches, for the reason that beaches are difficult to trace in a rugged region, while the valley terraces of that time of floods are very clear.

Lake Champlain. As the continent in late Pleistocene time rose to its present hight, the sea was drained off, but the great dam formed by the clay plain to the north changed the character of the drainage from that of the preglacial Champlain river to the present lake. The fresh water lake was at first 50 feet or more higher than now, but the Richelieu has lowered its channel to its present level since. The present lake lies mostly well above the preglacial channel, but the southern end seems to occupy that part of the old channel and is now little broader than a river.

In closing, I would express my thanks to Mr. Upham for many helpful suggestions, to Prof. Hitchcock for the loan of valuable maps, and to Mr. C. H. Richardson for his company and assistance in the field.

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*Baron De Geer, AM. GEOLOGIST, vol. xi, p. 36, Jan., 1893.

†AM. GEOLOGIST, vol. xi, p. 23.

EDITORIAL COMMENT.

THE COLUMBIAN EXPOSITION.

Notes on some Mesozoic and Tertiary Exhibits.

THE UNITED STATES GEOLOGICAL SURVEY.

The Survey presented in the Government building a synoptic exhibit under the caption of "Systematic Collection of Rocks and Fossils." This included a series of selected and prominent types of Mesozoic and Cenozoic rocks and fossils arranged primarily according to stratigraphic and geographic divisions, and subordinately, as to fossils, according to zoological and botanical relationships.

The maps showing the geographic distribution of the Eocene and Neocene and of the Cretaceous systems within the United States, exhibited in connection with the corresponding collections, were for their general pretensions reasonably accurate, as to those parts at least with which the writer is most familiar, one of the least satisfactory parts of the Cretaceous map being, perhaps, Kansas south of the Arkansas river. But no such map should be expected to present detailed accuracy.

The Tertiary collections were divided into Eocene and Neocene, and for the most part, without further attempt to specify the horizon, except as it might be implied in the geographical locality named on the label. The chief Eocene localities from which specimens were exhibited were, for Invertebrata, Jackson, Vicksburg, Caton's bluff, Claiborne, Wood's bluff, etc.; and for leaf impressions, Green river and Florissant. The Neocene fossils were given, in the main, only States as localities, exceptions being shells from "Yorktown, Va., Lower Neocene" and plants from Cherry creek and John Day valley, Oregon, and Coral Hollow, California.

The Cretaceous collections were primarily divided into Upper and Lower. In the Upper Cretaceous, a small series of fossils from the recently redefined Bear River formation constituted a feature of special interest. It included the following forms: *Campeloma macrospira* Mk., *Pyrgulifera humerosa* Mk., *Goniobasis cleburnii* White, *Corbula pyriformis* Mk., *Corbicula durkeei* Mk., *Unio vetustus* Mk., and *U. belliplicatus* Mk.

Two very interesting specimens of *Gryphæa* from the Colorado group of Huerfano Park, Colorado, were labelled "*Exogyra suborbiculata* Lamarck." From the same district and formation were specimens of *Trigonarca obliqua* Mk., and of the recently described *Cassidulus stantoni* Clark.

Examples of *Radiolites austinensis* from Ellis county, Texas, were remarkable for being labeled "Eagle Ford shales." If not so labelled by mistake, they extend the known stratigraphic range of this hippuritid.

The large Texan Timber Creek *Arca* (*Barbatia*) which, in his recent "Contribution to the Invertebrate Paleontology of the Texas Cretaceous,"* the writer described as constituting a slight and even doubtful variety (*tramitensis*) of *A. galliennei* D'Orb., and from which the *A. coalvillensis* White seems to differ, if at all, only in size, was exhibited under the name *Barbatia micronema* Mk." If the names *micronema* and *coalvillensis* represent but one variety, whose larger examples equal those of the Texas shell in size, and which is identical with it in detail of sculpture, the names *tramitensis* and *coalvillensis* must yield to the earlier name *micronema*, and the American variety would stand as *A. galliennei* D'Orb., var. *micronema* Mk. But whether the *A. galliennei*, from *any* of its American localities, shows differences sufficiently prevalent to constitute a local variety, is quite doubtful, as has been admitted in attempting to establish such a variety in the case of the Texas representative of the species.

The association in the Timber Creek sandstone of *Arca galliennei*, *Glauconia* ("*Turritella*") *renauxiana*, and the American analogue (*C. interlineatum*) of *Cerithium provinciale*, characteristic species of the Chloritic chalk of France, an occurrence recorded in the above-named "Contribution," is a significant fact, and would seem to indicate that these two formations are at least approximately synchronous.

The gasteropod that was labelled "*Glauconia coalvillensis* Mk. Colorado formation, Upper Kanab valley, Utah," in the Survey exhibit, is indistinguishable from specimens of the same species from the Timber Creek horizon of Texas. The *Turritella coalvillensis* of my "Contribution" and the *Turri-*

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*Fourth Annual Report of the Geological Survey of Texas. See pp. 168–170.

tella renauxiana of the same, and of D'Orbigny's Paléontologie Francaise, should undoubtedly both be referred to the genus *Glauconia*.

That there was in the collection, also from the "Upper Kanab valley," a specimen of the Eagle Ford ammonite, *Buchiceras swallovii* Shum., is noteworthy. The writer has a specimen of this species from northern Kansas, representing a broad phase of the species, close to one such that is of occasional occurrence in Texas.

It would be interesting to know concerning the specimen from the "Eagle Ford shales, Midlothian, Ellis county, Texas," marked "*Placenticeras placenta* DeKay ?" whether the variation indicated by the interrogation mark be in the direction of *P. syrtalis* Mort., or of the recently described var. *cumminsi* of that species. (See Fourth Ann. Rep., Geol. Surv. Tex., pp. 237–239.)

The Lower Cretaceous fossils exhibited were from the Comanche series and the Shasta formation.

The "*Modiola concentrice-costellata* Roem.?" is the recently described *M. stonewallensis*. The species occurs also in the Fredericksburg of southern Kansas, and was recorded by the writer from Belvidere, Kansas, several years ago under the erroneous designation of *Modiola burlingtonensis* Whitf.

An excellent specimen (? the type) of Hill's superb *Vola roemeri* from the Vola limestone of Travis county, Texas, was among the more striking features of this part of the exhibit.

The "*Cardium hillanum*" on exibit represented the *C. multistriatum* of Conrad, a phase of the subgenus typically developed in the Comanche Peak limestone, and common, for example, at Georgetown, Texas, and which is strikingly different from the common phase of the genus in the Washita division. The latter phase is particularly well seen in the Denison beds. It remains to be shown whether these two phases are only extreme varieties of one species or are constantly distinct.

The example of *Astarte* ("*Stearnsia*") *robbinsi* White ("20,137"—the type ?) is finely preserved. So far as could be seen, it did not show on the exhibited side any trace of the radial marks seen on the beaks in the type of *A. acuminata*

Cragin. It is not only much larger, but also apparently a coarser-featured shell than the latter.

A specimen of "*Trigonia emoryi*" from "Denison, Texas," is apparently a young example of *T. clavigera* Cragin. The "*Arcopagia texana*" is unquestionably a *Cyprimeria.* (See Contribution to Inv. Pal., etc., p. 177. For relation of *C. texana* to *C. crassa*, see also p. 176.)

ILLINOIS.

A part of one case in the large paleontological collection from this state, exhibited in the Illinois building, was devoted to the little corner of Cretaceous that intrudes itself within the otherwise severely Paleozoic borders of the state at its southern extremity.

A fine small-medium-sized specimen of *Exogyra costata* Say was labeled, "Cairo, Alexander Co. In a rock under the Ohio river. Struck in sinking a caisson for the I. C. R. R. bridge. Coll., S. W. Barton."

A tray of casts of undetermined fossils, in grayish brown (? Dakota or equivalent) sandstone, included several species of univalve and bivalve mollusks and a (? willow) leaf-impression, labeled, "Caledonia, Pulaski Co."

CANADA.

In connection with the Canadian Mining Exhibit, the Geological Survey of Canada found room for a paleontological collection, small, but representative of the leading geological divisions of the Mesozoic, including Triassic, Jurassic and Cretaceous, with divisions of the latter, and the Cenozoic of British America.

Time and opportunity were not sufficient to give this collection the attention it deserved, or indeed to note any of its features of special interest.

MEXICO.

In the excellent exhibit of mining and mineral resources of Mexico, displayed in the Mining building, was a small but interesting collection of fossils, a manuscript catalogue of which was kindly shown me by the courteous commissioner in charge, Prof. Carlos Sellerier. The catalogue enumerated about 128 species. Of this number, seventy-nine were listed as

Cretaceous, and at least seven others were certainly so, making a minimum of eighty-six Cretaceous species exhibited.

The collection included *Orbitolina texana* Roem., which in Texas belongs in beds—the Alternating beds or Glen Rose division—that geologists of the United States have generally included in the lower Cretaceous, but which was here assigned to the upper Jurassic.

FROM EVERYWHERE, AS EXHIBITED BY PROF. H. A. WARD, ROCHESTER, N. Y.

Vertebrate paleontology, which seems conspicuous for its *lack* of representation in most of the geological exhibits at the World's Fair, was represented by many leading fossils and casts in the comprehensive Mesozoic and Tertiary (as well as Paleozoic and Quaternary) collections which formed a part of the superb exhibit from Ward's Natural Science Establishment, in the Anthropological building, an exhibit of which it would be difficult to speak too highly; for whether it were vertebrates, invertebrates, plants, or rock-types, and these Paleozoic, Mesozoic, or Cenozoic, American or foreign, that one wished to see, they were there displayed in fine form for inspection.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Economic Geology of the United States. By RALPH S. TARR, Assistant Professor of Geology at Cornell University. 8vo., pp. xx, 509, illustrated. Macmillan and Co., New York, 1894. Price, $4.00.

Much has been done in the past quarter of a century toward popularizing the study of general geology. The descriptions of rocks and fossils and the physical and chemical changes which the earth has undergone and is still passing through, have been couched in untechnical language and a general knowledge of them is now possessed by many who are not specially educated as geologists. For the science of economic geology, however, this important work has not been so well performed. It is only a specialist who can pretend to a knowledge of the natural inorganic products of our country, and even his information must often be derived from personal examination, or by laborious research into the geological reports and the wide-scattered technical literature. The only text-books available until recently have been mere primers, containing the barest outline of description and some tables of statistics.

The book before us is intended to supply this deficiency and to furnish also an accurate account of our mines and valuable rocks and minerals, and their importance as compared with other countries. Beginning with a clear and readable presentation of the geological truths necessary for an understanding of the various deposits described later, the first 70 pages are devoted to a discussion of common minerals and rocks and the influence of physical geography and topography on the distribution and extent of ore deposits. The origin of ore deposits, and the methods of mining are treated in the next 40 pages of Part I. Part II discusses the metalliferous deposits in the order of their importance to man, beginning with iron. This occupies nearly 200 pages; while 150 pages are devoted in Part III to the non-metallic mineral products.

There is an appendix consisting of a list of treatises on economic geology and ore deposits in general or upon particular subjects. This is very poor, and will be of almost no value to a reader unfamiliar with the subject. He would not know where to procure many of the works listed nor what their size, or value. Such a list should contain complete data as to the name of the author, date and place of publication, together with the names of the publishers and size and cost of the volume. There is a good index which adds to the usefulness of the work. The illustrations are well-drawn and clearly printed.

A treatise of this sort might be written from many points of view, geological, chemical, mining, statistical or metallurgical. This is evidently from the standpoint of a geologist, and it is not strange therefore that it is strongest and most explicit in its statement of geological facts, although the statistical side is also very well cared for, and there is a fund of varied information on all branches of the subject treated.

The style of the work is easy and entertaining, but the statements are not always made with perfect accuracy. At the risk of appearing hypercritical regarding a work which contains so much that is commendable, we shall mention a few points where there is a chance for improvement, or, at least, for difference of opinion. On page 2, for example, we find that "upon the surface (of the earth) nearly all of the elements are in chemical combinations of greater or less definiteness, and these are called *minerals*." The definition is loose. The majority of combinations of elements on the surface of the earth are not minerals. Again, on page 80, ore deposits are divided into three main classes: 1. Eruptive; 2. Mechanical; and 3. Chemical. But since all the operations of nature are primarily chemical or the result of chemical action, the classification evidently refers to the kind of action which has had for its direct and immediate result the production of the ore in the place where we find it. If this view be taken, it seems that the division "eruptive" is not coördinate with "mechanical" and "chemical," but should rather be a division under "mechanical," of equal rank with "sedimentary." All eruptions are produced by the direct operation of physical forces. In fact, it would seem that all natural operations must be either mechanical or chemical. Otherwise the classification of ore deposits presented here is a good, working arrangement, and much better than many that have been proposed. The statement on page 81 that "there is no deposit of ore known to be of eruptive origin, which is at present worked," is not strictly true. Under "mechanical" ore deposits we find only tin, gold and platinum placers as examples, thus excluding iron sands and the "recomposed" iron ores of Michigan described by Wadsworth and Van Hise.

The "simplest illustration" of "precipitated deposits" is not clearly given (page 82). Bog iron ore is not formed by the transportation of hydrated sesquioxide of iron in solution and its precipitation in the presence of certain vegetable acids, but rather by the carrying of carbonates and other salts of iron in solution through the aid of these vegetable acids and their precipitation as hydrated sesquioxide of iron on being oxidized by the atmosphere and oxygenated waters.

We notice a careless use of the term "boulders" on page 98, where it is used to signify the "float" or masses detached from a vein and rolled down the hillside. Again, on page 99, the "country rock" is said to be "sharply defined," meaning rather the vein or its walls. On page 114 the term "calcine" is said to mean "to allow ores to decompose in the air at ordinary temperatures," which is of course incorrect. The following proper names are misspelled: Chamberlin, Andreasberg, Wöhler, Lottner, and Mesabi.

It is a good idea to teach the student the intimate connection between rocks and ore deposits. Our author dwells on the fact that all rocks contain ores and that the most probable source of all our valuable minerals is the eruptive rocks. When the reader once realizes that all rocks are incipient or potential ore deposits he first perceives the necessity of a knowledge of geology in order to be successful in mining. The secondary processes which operate to bring about the concentration of these disseminated ore-particles are also well described. The all-important agency of *circulating* waters is occasionally overlooked, however, as for instance on page 126, where standing water is said to account for the replacement of limestone by iron ore on the Gogebic range. The better supposition is that the waters flowed along the pitching trough, formed by the intersection of the dikes and the quartzite, and that the ore was deposited at the confluence of the ferriferous waters, which had percolated down through the ferruginous cherts, with the oxygenated waters which came more directly down on top of the quartzite from the surface.

The condition of the Canadian iron mining industry and its future prospects are rather facetiously described by the remark that there are undoubtedly "great possibilities in store" for the iron industry of Canada.

The iron ores of Cuba are not mentioned, although they are of vastly greater importance in this country than the ores of Elba or Spain. The author is evidently not familiar with Prof. Kimball's account of the formation of the Cuban ores by the "isomorphous and pseudomorphous replacement of limestone," which is one of our most valuable memoirs on the subject.

The idea that iron mines are all worked in open pits is so frequently expressed that it seems necessary to call attention to the fact that nearly all of the iron mines (150 or more) of the lake Superior region are underground and have attained depths varying from 400 to 1,600 feet.

No particular mention is made of the Homestake gold mine in the Black Hills, although it is an important producer and well illustrates one class of gold mines,—those contained in a belt of crystalline schists. The occurrence of native silver in calcite veins in the Silver Islet and other mines of Thunder bay is also overlooked.

On page 210 the depth of the Calumet and Hecla copper mine is incorrectly stated to exceed 4,000 feet; and on page 269 we are told that manganese is less valuable than iron and therefore not ordinarily mined unless collected into extensive beds, neither of which statements is strictly true.

There is a valuable chapter on coal and another on petroleum and natural gas. On these products, as on building stones, clays, cements, and soils, the information is accurate and up to date. Rock salt is rather briefly mentioned, but here as throughout the book the author has availed himself of the most recent statistics as to production.

The work is a welcome addition to our scanty literature on mineral products and is exceedingly creditable to its author. It is gratifying to learn that it has already been adopted in ten or more colleges as a text-book. For general students it is admirable, but for mining engineers something like Kemp's "Ore Deposits of the United States," more specific in description and exact in reference, will be used.

H. V. W.

Geology of the Boston Basin. Vol. i, Part i.—Nantasket and Cohasset. By WILLIAM O. CROSBY. (Occasional Papers of the Boston Society of Natural History. IV.) Pp. 177, with two maps, four plates, and 23 figures in the text. 1893. This is the first of a series of memoirs to treat of the geology of the area reaching to distances of five to fifteen miles or more from Boston, Mass., upon which the author has devoted much observation and study from the time of his publication of a geological map of the district for the Philadelphia Centennial Exposition in 1876. The tract here described is the peninsula of Nantasket, enclosing Boston harbor on the southeast, with the adjoining mainland township of Cohasset. The very ancient lava flows of the Boston basin and their relations to the interstratified conglomerate (Roxbury puddingstone) are here observed better than in any other localities. Professor Crosby shows that the melaphyrs and porphyrites were mainly contemporaneous lavas poured out on the sea-floor at different times during the deposition of the beds of conglomerate and sandstone. The granite and diorite of the area are newer than the Cambrian slates of Braintree and Weymouth; it is also clear that the conglomerate and melaphyr sheets are newer than the granite and therefore more recent than Middle Cambrian. They are regarded as certainly Paleozoic, but whether referable to the later Cambrian or possibly to the Carboniferous period, which is well represented in the neighboring Narragansett basin, remains to be determined.

The Cretaceous System in Canada. By J. F. WHITEAVES. Presidential address in Trans., Roy. Soc. Canada, section iv, 1893, pp. 3–19. This is a valuable discussion of the present state of knowledge of the Cretaceous strata in Manitoba and the country extending thence west to the Rocky mountains and to the Pacific. Including the Laramie formation, the total number of known species of Cretaceous fossil plants in Canada is 179, and of animal remains 394. Only comparatively small portions, however, of the rocks of this system in Canada have been examined in detail.

Note on the recent discovery of large Unio-like shells in the Coal Measures at the South Joggins, Nova Scotia. By J. F. WHITEAVES. Trans., Roy. Soc. Canada, sec. iv, 1893, pp. 21–24, with a plate. The species (*Asthenodonta westoni*) here described and figured was found associated with large fragments of *Sigillaria* and *Lepidodendron* and leaves of *Cordaites*. It measures nearly 8 inches in length, with a width of 3¼ inches.

Eleventh and Twelfth Annual Reports of the New York State Geologist. These reports, for the years 1891 and 1892, the publication of which had been delayed by the burning of the state printing house at Albany, have now appeared under the dates of 1892 and 1893. The Eleventh report is a royal octavo of 296 pages, the most important part of which (169 pages) is "An Introduction to the Study of the Brachiopoda, intended as a Handbook for the use of Students," by JAMES HALL, assisted by JOHN M. CLARKE. This has about 100 pages on the distribution, habits, anatomy, and development of the brachiopods, which are followed by generic diagnoses based largely upon the determinations made in volume VIII, part 1, of the Palæontology of New York. The whole is accompanied by 286 zinc-types, 22 lithographic plates, and a map showing the distribution of the recent brachiopods. A concluding part of the work is to follow in a subsequent report. In addition to this paper the report contains a brief statement of the work of the department, a list (23 pages) of the fossils in an important donation from the Albany Institute, containing many of the originals of Green's "Trilobites of North America" and of the cephalopods described in Pal. N. Y., vol. I; also an elaborate "List of the original and illustrated Specimens in the Palæontological Collections: Part 1, Crustacea" (66 pages), and a paper "On Cordania, a proposed New Genus of Trilobites," by JOHN M. CLARKE.

The Twelfth report (8vo., 142 pages) contains, in addition to the reports of the geologist and palæontologist, a continuation of the list of type specimens (Annelida and Cephalopoda, 50 pages) and also the following: "Notes upon two boulders of a very basic eruptive rock from the west shore of Canandaigua lake, and their contact phenomena upon the Trenton limestone," by B. K. EMERSON; and "The Devonian Section of Central New York along the Unadilla River," by CHARLES S. PROSSER.

Om en Hemipter från Sveriges undre Graptolitskiffer; by JOHANN CHR. MOLSERG (Geolog. Förening. i Stockholm Förhandlingar, vol. XIV, pp. 121–124).

The author has found a bed-bug (Protocimex siluricus) in the graptolite shales of Sweden.

The Evolution of the Brachiopoda; by AGNES CRANE.

The Brighton Herald of Dec. 16, 1893, publishes a very full abstract of Miss Crane's paper prepared for one of the scientific congresses of the recent Columbian Exhibition and re-read before the "Brighton and Sussex Natural History and Philosophical Society." It is a lucid and forcible presentation of the subject by a student thoroughly in touch with the abundant and important results achieved in this field of investigation during the last few years; gracious in its acknowledgments, and interspersed with lively and interesting reminiscence of the late Thomas Davidson, whose name will always bear the *Cæsarea majestas* in matters brachiopodous. The following passage from this abstract seems worthy of reproduction: "It was shown that synthetic or mixed types were by no means rare, reversionary or atavistic forms not uncommon; that the study of individual development of larval forms of recent species reveals long past phases in the history of the origin of genera, which agree geologically with their chronogenesis or birth in time. The existence of numerous passage forms, intermediate in structure between the hingeless and hinged subclasses, showed those divisions were not based on fundamental distinctions. Ordinal evolution was conclusively demonstrated and numerous instances were given of the successive 'paterine,' 'obolleloid' and 'linguloid' characters of ancient genera. Instances of development on parallel lines were cited in the families *Lingulidæ*, *Rhynchonellidæ* and *Terebratellidæ*. The lecturer paid a passing tribute to Madame Pauline Oehlert as the only other member of her sex who was actively interested in the study of the Brachiopoda."

Causes of Magmatic Differentiation. By Helge Bäckström. (Journal of Geology, vol. i, No. 8, pp. 773–779, Nov.,-Dec., 1893.)

The author thinks that "Soret's principle" cannot be applied to the differentiation of igneous magmas, for we do not know what is the solvent and what the thing dissolved, nor does it seem right to apply the laws of dilute solutions to magmas before attempting to consider them simply as mixtures of liquids. He gives an illustration of how two liquids, aniline and water, mix at different temperatures; it is found that the mixture separates into two layers, which contain different amounts of the two liquids, and the relative proportions of the liquids vary in the layers according to temperature, mixing more readily as the temperature increases, and finally, when sufficiently heated, mixing in all proportions. The different parts of a rock magma may perhaps act in this way, mixing in all proportions at high temperatures, and on partial cooling may separate into two or more parts by *liquation.* The author then selects two cases, basic inclusions and the great petrographical province of Iceland, and examines them briefly in the light of both theories, *i. e.*, differentiation due to Soret's principle and that due to liquation. In these cases the latter theory seems to explain the facts better. "The purpose of this communication is to give to liquation and not to diffusion its place in the working hypothesis, upon which the theory of differentiation is to be constructed. How far this theory may differ from the approximation to it given by Rosenbusch in his 'Kern' theory, the future will show." G.

Genetic Relationships among Igneous Rocks. By JOSEPH P. IDDINGS. (Journal of Geology, vol. i, No. 8, pp. 833–844, Nov.–Dec., 1893.)

Under "Studies for Students" Prof. Iddings has presented in a clear and simple manner some of the data and opinions bearing upon the genesis of different kinds of rock magmas. The results of differentiation, the gradual passage from one rock type to another and the sequence of eruptions are briefly discussed, and special attention is directed to the existence of distinct and well characterized petrographical provinces. A distinction is noted between the idea conveyed by the term *rocks* as ordinarily used and that which is involved in the expression *rock-body* as a geological unit. G.

Annals of British Geology, 1892. A digest of the books and papers published during the year—with occasional notes. By J. F. BLAKE. (Pp. i–xliv, 1–310; 7 plates; 8vo; Dulau & Co., London, 1893.)

This book gives a compilation of all that has been written on the geology of the British Isles during the year 1892. The various articles are divided into different groups and under each title is an abstract giving the gist of the article; sometimes these abstracts are several pages in length. Many of the abstracts have been submitted to the various authors for correction and approval, and in such cases this fact is indicated, thus making the abstracts all the more valuable. The author has wisely refrained from indulging in any discussions or criticisms of his own in connection with the abstracts; such discussions and criticisms are brought together in the form of introductory review. Among other things in this review it is noticed that the results as to the recentness of the end of the Glacial period, obtained by a study of the recession of St. Anthony falls and of Niagara falls, are questioned, and the author concludes: "If, then, the American glaciation only dates back as far as that (7,000 years), it cannot belong to the same period as ours; there must have been two glacial epochs, one in the old world and another in the new." All the new species of British fossils described during the year, except those in the Palæontographical Society's volumes, are figured and a selection of other illustrations is made. This book represents a great deal of work and will be a valuable aid to all geologists, especially to those who do not have access to a library which contains the recent geological literature. G.

RECENT PUBLICATIONS.

I. Government and State Reports.

Geol. Sur. of Ark., Vol. 4, 1890, contains: Marbles and other limestones, T. C. Hopkins; The faults of the marble region of North Arkansas, T. C. Hopkins; Geologic map of the marble region of Arkansas, J. C. Branner and T. C. Hopkins.

Calif. State Mining Bureau. 11th report of the State Mineralogist for two years ending Sept. 15, 1892, Wm. Irelan, Jr., State Mineralogist.

Geol. Sur. of N. J., Annual report for 1892 contains: Surface geology, R. D. Salisbury; Preliminary report of the Cretaceous and Tertiary formations of N. J., W. B. Clark; Water supply and water power, C. C. Vermeule; Artesian wells in southern New Jersey, L. Woolman; Notes on the sea-dikes of the Netherlands, and the Reclamation of the lowlands of the Netherlands, J. C. Smock.

The climatology and physical features of Maryland: First biennial report of the Maryland State Weather Service, for the years 1892 and 1893. Wm. B. Clark, Director. 140 pages. Baltimore, 1894.

Fourth annual report of the Inspector of Mines, for the State of South Dakota. W. S. O'Brien, Inspector. 19 pages; Lead, 1893.

Mineral resources of the United States, 1892. By David T. Day. 850 pages. U. S. Geological Survey, Washington, 1893.

Bulletin No. 3 of the Illinois State Museum of Natural History contains: Descriptions of some new species of invertebrates from the Palæozoic rocks of Illinois and adjacent states, S. A. Miller and W. F. E. Gurley.

II. Proceedings of Scientific Societies.

Bull. Geol. Soc. Amer., vol. 5, pp. 39-70, Nov., 1893, contains: Origin of the Pennsylvania anthracite, J. J. Stevenson.

Trans. Wisconsin Acad. Sci., Arts and Letters, vol. 9, pt. 2, 1893, contains: Geology of the Waterloo quartzite area (Plates 7-9), I. M. Buell.

Bulletin of the American Museum of Natural History, Vol. 5. 1893, contains: Artionyx, a new genus of Ancylopoda, H. F. Osborn and J. L. Wortman; Aceratherium tridactylum from the Lower Miocene of Dakota, H. F. Osborn; On the divisions of the White River or Lower Miocene of Dakota, J. L. Wortman; Ancestors of the tapir from the Lower Miocene of Dakota, J. L. Wortman and Charles Earle; Fossil mammals of the Upper Cretaceous, H. F. Osborn.

III. Papers in Scientific Journals.

Amer. Jour. Sci., Vol. 47, Jan., 1894, contains: Petroleum in its relation to asphaltic pavement, S. F. Peckham; The age of the extra-moraine fringe in eastern Pennsylvania, E. H. Williams, Jr.; Notes on the Cambrian rocks of Pennsylvania, from the Susquehanna to the Delaware, C. D. Walcott; Postglacial eolian action in southern New England, J. B. Woodworth.

Jour. of Geol., Vol. 1, No. 7, Oct.–Nov., 1893, contains: Geologic time as indicated by the sedimentary rocks of North America, C. D. Walcott; On the Origin of the Pennsylvania authracite, J. J. Stevenson; The basic massive rocks of the Lake Superior region, W. S. Bayley; On the geological structure of the Mount Washington mass of the Taconic range, W. H. Hobbs.

Jour. of Geol., Vol. 1, No. 8, Nov.–Dec., 1893, contains: The supposed glaciation of Brazil, J. C. Branner; Causes of magmatic differentiation, Helge Bäckström; The geological structure of the Housatonic valley lying east of Mount Washington, W. H. Hobbs; The Newtonville sand-plain, F. P. Gulliver; The structures, origin and nomenclature of the acid volcanic rocks of South Mountain, F. Bascom; Studies for Students —Genetic relationships among igneous rocks, J. P. Iddings.

IV. Excerpts and Individual Publications.

Annual report of the St. Louis Public Library, F. M. Crunden, 1891-92.

On the nature of the chemical elements: The distribution of the atomic weight, C. S. Palmer. Extr. Proc. Colo. Scien. Soc., Nov., 1893.

Notes on some fossil plants from the Trinity division of the Comanche series of Texas, W. M. Fontaine. Proc. U. S. Nat'l Mus., Vol. 16, No. 934.

A basic dike in the Connecticut Triassic, L. S. Griswold. Bull. Mus. Comp. Zool., Harvard College, Vol. 16, No. 14. (Geol. Series, Vol. 2.)

Petrography of the gneisses of the town of Gouverneur, N. Y., C. H. Smyth, Jr. Contr. Geol. Dept. Columbia College, No. 11.

Production of coal in 1892; E. W. Parker. From Report of Statistics, 1892.

A preliminary report on the Cretaceous and Tertiary formations of New Jersey, W. B. Clark. From the Geol. Survey Report, New Jersey, 1892.

The great Mesozoic fault in New Jersey, B. S. Lyman. Proc. Am. Phil. Soc., vol. 31, No. 142, Sept., 1893.

The Cretaceous system in Canada, J. F. Whiteaves. Presidential address. Trans. Roy. Soc. Can., Section 4, 1893.

The future of silver, Eduard Suess. Translated by R. Stein, U. S. Geol. Survey, 1893.

On the Thoracic legs of Triarthrus, C. E. Beecher. Amer. Jour. Sci., vol. 46, Dec., 1893.

The recent discovery of large Unio-like shells in the coal measures at the South Joggins, N. S., J. F. Whiteaves. Trans. Roy. Soc. Can., Section 4, 1893.

The geology of Nashville and immediate vicinity, P. M. Jones.

Geological map and table of economic resources of Illinois, D. W. Mead. Notes on the hydro-geology of Illinois in relation to its water supplies, D. W. Mead.

Natural science at the Chicago exhibition, F. A. Bather. Natural Science, Vol. 3, No. 21, Nov., 1893.

Nickel: Historical sketch, W. L. Austin. Read before the Colorado Scientific Society, Dec. 4, 1893; 26 pages.

Nickel: The occurrence, geological distribution and genesis of its ore deposits, Philip Argall. Read before the Colorado Scientific Society, Dec. 4, 1893; 32 pages, 2 plates.

Economic geology of the United States, with briefer mention of foreign mineral products. By Raiph S. Tarr. Pp. i–xx, 1–509; New York and London, Macmillan and Co., 1894. Price, $4.00.

Observations on the geology and botany of Martha's Vineyard, Arthur Hollick. Trans. N. Y. Acad. Sci., XIII, pp. 8–22, 1893.

The ore deposits at Franklin Furnace and Ogdensburg, N. J., J. F. Kemp. Trans. N. Y. Acad. Sci., XIII, pp. 76–98, 1893.

V. Foreign Publications.

Société Géologique du Nord, Annales XX, 1892, contains: *1. Terrains primaires*: Sur la composition des terrains primaires des Pyrenées, par M. J. Roussel; Observations sur le terrain devonien de la catalogue, par M. Ch. Barrois; Mémoire sur la distribution des graptolites en France, par M. Ch. Barrois; Etude stratigraphique sur les calcaires de Vise, par MM. Horion et Gosselet; Premières rèmarques sur le Boghead d' Autun, par MM. E. Bertrand et Renault; Compte-Rendu de l' excursion gèologique dans l'Eifel, par M. L. Desoil; Decouverte de Radiolaires dans les schistes graphitiques du terrain azoique de la Bretange, par M. Ch. Barrois; Compte-rendu d'une excursion dans les environs d'Avesnes. par M. Parent. *2. Terrains secondaires:* Sur les conditions de dépots de la Craie blanche, par M. O. de Grossouvre; Coupe du terrain Crétacé à la fosse, No. 5, à Divion, par M. Gosselet; Sur la presence de nombreuses diatomées dans les gaizes jurassiques et Crètacées du bassin de Paris et de l'existence des Radiolaires dans les gaizes Crétacées de ce meme bassin, par M. L. Cayeux; Sur le Corallien de la region de Lerouville, par M. Jannel; Sur la composition du terrain Crétacé des Pyrenées centrales et des Corbières, par M. J. Roussel; Etude sur la Craie à *Micraster* du Boulonnais et sur les plissements de la Craie dans cette region, par M. Parent. *3. Terrains tertiaires:* Compte-rendu d'une excursion au Cateau et à Solesmes, par M. Bardou; Sur les grès à silex de Beuzeville et sur l'argile à silex blanchis, par M. Gosselet; Sur les phosphates de Chaux du Tarn et du Tarn-et-Garonne, par M. Helson. *4. Terrains quaternaires et recents:* Essai sur la constitution géologique du terrain quaternaire des environs de Mons, par M. Ladrière; Sur les alluvions récents de la vallée de l'Oise, par M. Rabelle; Compte-rendu de l'excursion dans le quaternaire du Nord, de la France et de la Belgique, sous la direction de M. Ladrière, par M. Parent; Compte-rendu de la reunion annuelle de la Société Géolgique du Nord, a Saint-Omer, par M. Parent; Compte-rendu de l'excursion au Cateau et à Solesmes, par M. Bardou; Remarques sur l' origine de la plaine maritime, par M. Gosselet. *5 Paléontologie:* Description de quelques oursins nouveaux de la Craie blanche, par M. Parent.

Second Report of the Bureau of Mines, Ontario, Archibald Blue, Director, 1892.

Geol. Surv. of Canada. Catalogue of Section I of the Museum of the Geological Survey, G. Christian Hoffman, 1893.

Une excursion géologique dans les Montagnes Rocheuses, M. Marcellin Boule. Assoc. Francaise l'Advancement des Sciences, 1893.

Variétés: L'homme paléolithique dans l'Amerique du Nord, M. Boule.

The Mount Morgan gold mine, Australia, F. W. Sykes, 1892.

The work of the Geological Survey, A. Geikie. Trans. Federated Inst. Mining Engineers, Vol. 5, pp. 142-168, 1893.

Report of the Director-General of the Geographical Survey and Mus. of Practical Geology for 1892, A. Geikie. Extr. 40th Rep. Sci. and Art Dept., 1893.

Réunion extraordinarie dans la Velay et la Lozere, Sept. 14-24, 1893. Compte-rendu des séances de la Soc. Geol. de France, No. 14, 1893.

Discussion of certain dissimilar occurrences of gold-bearing quartz, T. A. Rickard.

Catalogue of a stratigraphical collection of Canadian rocks prepared for the World's Columbian Exposition, W. F. Ferrier. Geol. Sur. Canada, 1893.

Datos para la Geologia de Mexico, Jose G. Aguilera and Ezequiel Ordonez, 1893.

VI. Proceedings of Scientific Laboratories.

Bulletin of the Department of Geology, University of California, Vol. 1, No. 3, Dec., 1893, contains: The eruptive Rocks of Point Bonita, F. Leslie Ransome. Vol. I, No. 4, Dec., 1893, contains: The Post-Pliocene diastrophism of the coast of southern California, A. C. Lawson.

CORRESPONDENCE.

SOME CONDITIONS OF RIPPLE-MARK. In a recent number of the AMERICAN GEOLOGIST,* an interesting occurrence is described of highly inclined bedding in a glacial sand-plain. This is explained as false bedding, on the ground that the real bedding consists of very faintly visible ripple-marked layers, nearly horizontal, that have been deposited through a considerable thickness in regular series, the ripples in successive beds conforming precisely to those below. This is accounted for by a uniform current in one direction, depositing at a uniform rate materials "varied in point of size and weight," which became assorted by the rippling action, the larger fragments coming to rest in the troughs and the sand being packed closely on the long slopes of the ripple ridges. In this way a false bedding was built up by successive ripple-troughs and successive ripple-crests, dipping about forty degrees in the direction from which the ripple-forming current flowed. The section exposed is described as one hundred yards long and fifteen to twenty feet high; the ripple-marks have "regular and unvarying form," and the larger pebbles have an average diameter of two to two and a half inches.

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*"False bedding in stratified drift deposits." By J. E. SPURR. Vol. XIII, January, 1894.

Now there are certain points in this explanation which do not quite accord with the results of experimental work on ripple-marks, nor with the facts observed elsewhere in the field in either ripple-marked sandstones or recent detrital material. Ripple-mark cannot be reproduced in the laboratory in material consisting of mixed pebbles and sand; this is true of marks formed by single currents in one direction, as well as of regular ripple-mark formed by oscillation. This I have proven by experiment, and it is confirmed by observations of Messrs. Darwin* and De Candolle.† In recent stream beds and on sea beaches, ripple-mark is found only on surfaces of homogeneous sand; in pebbly areas the ripple-mark cannot exist, as the larger fragments interfere with the growth of the vortexes, to which, as Prof. Darwin has shown, ripple-mark is due. Fossil ripple-mark is almost invariably limited to sandy beds; it occasionally occurs in arenaceous clays and fine-grained limestones, but never in conglomerate. This statement is based on an extended examination of the literature, and on personal field observation. Furthermore, ripple-mark formed by a continuous current in one direction is irregular, migratory, and continually changing in form, and has been so distinguished by experimenters,‡ from *regular* ripple-mark formed by harmonic oscillations of water in contact with a sandy bottom. In sandstone strata, continuous series of rippled layers, crest over crest and trough over trough are very rare. Scrope§ noted this as early as 1830, observing that the upper and lower surfaces of a single ripple-marked slab do not correspond, when the lower surface retains the cast of the marks below.

In the section described in Minnesota, assuming even that a current could form regular marks in mixed material, it seems improbable that the velocity and rate of deposition of the stream remained absolutely uniform while fifteen or twenty feet of stratified sediment was added to its bottom; and in any case the continual shifting of the marks would be more than likely to produce great irregularties in the supposed false bedding. Finally, could ripple-mark exist at all in a current of sufficient velocity to "sweep along pebbles the size of an egg"? A current of less than one half of this velocity is quoted by Lyell as sufficient to "tear up fine gravel." In such case a current flowing two miles an hour would certainly tear up fine sand.

It is of course impossible to do more than suggest an explanation which will replace that based on the presence of ripple-mark. The occurrence as described, however, is strikingly similar to the fore-set beds of the ideal sand-plain figured by Prof. Davis.¶ It is possible that the inclined layers may actually be the true bedding, deposited obliquely in the manner characteristic of fore-set beds. They would naturally contain much coarse material near the head of the sand-plain, and become finer-grained towards its front; the suggestion that the supposed ripple-marked layers "when not obscured, might be easily mistaken for a minor cross-bedding," accords with this hypothesis, for cross-bedding is a frequent accessory of fore-set deposits.

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*George Darwin, Proc. Roy. Soc., vol. XXXVI, No. 228, Nov. 22, 1883. I. "On the formation of ripple-mark."

†Casimir de Candolle, Arch. des Sci. Phys. et Nat., Geneve, vol. IX, No. 3, 1883. "Rides formees, etc."

‡Darwin, De Candolle (v. s.), also A. R. Hunt, Proc. Roy. Soc., vol. XXXIV, April 20, 1882. "On the formation of ripple-mark."

§Poulett Scrope, Proc. Geol. Soc., London, vol. I, No. 21, March 2, 1831.

Lyell, Principles of Geology, 1889, p. 342.

¶ Bulletin Geol. Soc. America, vol. I, p. 197.

Harvard University, January 30, 1894. T. A. JAGGAR, JR.

OSCILLATION AND SINGLE CURRENT RIPPLE-MARKS. Through the kindness of the editors, the writer is enabled to reply to the foregoing communication in this number. The comments in the preceding letter are very suggestive, and doubly valuable on account of the acknowledged familiarity of the contributor with his subject. In defence of my position, I desire primarily to emphasize certain features which were only casually touched upon before, it being considered that this brief treatment was sufficient for the importance of the subject in hand. The cut from which the section for description was taken is, as before stated, "in a level plain of sand and gravel," and not "in a glacial sand-plain," that is, a delta plateau. There appeared to the writer no evidence that it was a delta formation. The dimensions given, it must also be pointed out, are those of the cut alone. The "level plain" in which it is made is part of an immense sheet of stratified drift which covers the surrounding country, and which usually shows a remarkable lack of topographical peculiarities.

The material in this cut varies in coarseness from a fine sand to a type made up mainly of pebbles, with all gradations between the two. The transition from one phase to another is vertical, so that thick horizontal beds of coarser and finer material alternate. These beds, where they are individualized by a more sudden change of material than usual, may be stated as being from three to ten feet in thickness. Ordinarily, the change from one to another is not striking, but occasionally the difference of average texture is great. Within these larger horizontal divisions, marking the coarser alternations of the true bedding, there may be a minor diversity in the size of material at different horizons, or, more often, the material is so nearly uniform that the gradations are hardly discernible. In the finer sand, there are successive continuous horizontal laminations which are as beautifully marked and as distinct as in any stratified sand deposit whatever; but instead of being perfectly straight, they are undulating and follow the familiar outline which is peculiar to the ripple-mark formed by a strong and constant current. In the material of mixed sand and pebbles, these lines of successive lamination are fainter, but they may be distinguished and traced continuously in almost every case. In the material which is made up mainly of pebbles the lamination becomes still fainter, and often entirely disappears. Between the cleanly marked lamination of the sand and the nearly obliterated stratification of the pebbles there is, of course, every possible gradation.

The ripple-marked laminæ generally nearly coincide with one another, crest for crest, and trough for trough, except for the slight forward movement of each new crest and trough. Figure 1 in the article in the January number of the AMERICAN GEOLOGIST expresses this relation of the successive laminæ, and if other lines were superadded to *a*, *b*, and *c* till the whole space of the figure were filled, a very fair idea of the actual appearance of the lamination in one of these sandy beds might be obtained.

This structure is best marked where there are no pebbles mixed with the sand, for then there are fewer phenomena to obscure it and distract the attention. The lines of the growth which each individual ripple-mark traces in its onward and upward movement are strongly marked. In material of uniform fine sand, weathering brings out this structure very strongly, for the looser and more rapidly formed parts which accumulate on the steeper slope fall away first, leaving the harder parts standing out as ridges. In those commoner horizontal beds which are of predominating sand, mixed with some coarser material and pebbles, the corresponding structure, shown in figure 2 of the above-mentioned article, is ordinarily found, providing that the relative proportion of sand and gravel is nearly constant, in all the horizons of the bed. This structure differs from that in the beds of homogeneous sand only in that the loose fine sand becomes mixed with coarser material and occasionally pebbles. As the pebbles begin to predominate, the false bedding, as well as the lamination of the true bedding, tends to become obscured and to disappear.

To sum up, we have in this cut three distinct banded structures, two of which are horizontal and the third inclined at a considerable angle. The first is a series of thick horizontal beds which differ from one another in the average size of material. At a distance this structure is very plain, but at close quarters the chances are that it would escape observation. The second is a series of finer horizontal layers, constituting the ordinary bedding of stratified deposits. This structure is best developed in the most sandy beds, and in proportion as the amount of coarser material increases it becomes obscured and finally disappears. The third is found developed to any noteworthy extent only in those beds which were formed with practically the same texture: any change in texture destroys the continuity of these layers, and therefore the same layer cannot extend from one bed into another. This structure follows and marks the lines of growth traced by each point of the horizontal ripple-marked layers. Each of the larger divisions shows this in a greater or less degree, and though the layers are not continuous in the different beds, yet they are parallel, and give the impression of a continuous stratification. This coarse and steeply inclined striping is, except at close quarters, the most striking structural feature in the deposit; but when very near, its importance is seen to be slight in beds consisting only of sand.

The first two structures show that the deposit was laid down in successive horizontal layers, and it then follows that the third, which traverses the first two, must have been formed under the same conditions. The constant relation of certain layers of the steeply inclined banding to certain parts of the ripple-marked lamination, the regular and continued alternation of the coarse and loose with fine and firm material, the thickness of these layers being always the same,—these seem to the writer to be sufficient evidence of the correctness of the explanation given in the January GEOLOGIST. If, as suggested, the layers are the true fore-set beds of a sand plain, the explanation of the continued recurrence, over a horizontal distance of many yards, of similar layers, separated always one from another by a constant distance of several inches, will be difficult. But the presence of the true bedding does not admit such an hypothesis.

In reconciling this conclusion with the observations of previous observers upon the subject of ripple-marks it is necessary to insist upon the distinction between those ridges formed by the oscillation of water upon a sandy bottom and denominated "regular" by Darwin and others, and those which are formed under a single current, called "irregular" by the same investigators. To the former class belong nearly all the examples which are found on sea-beaches and shallow lake bottoms, and which, on account of their being by far the commoner, have been chiefly studied. It is here that the restrictions urged in Mr. Jaggar's communication are applicable. The places where these are formed not being seats of rapid deposition, there is at the beginning of the period of formation of the ripple-mark the same material as at the end. Further the oscillations are relatively slight, and the resulting vortexes comparatively weak, so that, although they are quite sufficient to move sand, they fail at coarser material or pebbles, and as a result the growth of the vortex is broken and the ridge is not completed. Thus it happens that the oscillation ripple-mark is never found in pebbly beds; but only where all the materials are fine enough to be moved easily. All preglacial fossil ripple-marks which the writer has seen come under this head. Owing to the instability of the oscillating currents and the consequent incessant shifting of the vortexes, it is by the merest chance that successive ripple-marked surfaces coincide; and, in view of the length of time which generally separates two layers, such rare coincidences must be regarded as accidental.

To the second class belong those ripple-marks with which we have to deal. Because the limit of the strength of the single current is indefinite, the strength of the resulting vortexes may also become indefinitely great. So these ripple-marks are characteristically developed on a larger scale than the former class,—they are higher and the distance from crest to crest is greater.* Under the pressure of the current they move forward, but with so little change of form and relative position that the movement will ordinarily be overlooked, unless a mark is set. The variety of single-current ripple-marks formed by wind on dry sand has been chiefly described by geologists.† This structure is figured by

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*Dana, Manual of Geology, second ed., p. 672; third ed., p. 684.

†Lyell, Principles of Geology, p. 342. Prestwich, Geology, vol. I, p. 146. Geikie, Text-book of Geology, p. 335 (1893).

Lyell,[*] in a diagram showing the outline of the marks, and De La Beche has figured the manner of the forward progress. The latter figure has been reproduced by Geikie.[†] For the relative symmetry of single-current and of oscillation ripple-marks compare these figures and that of the writer in the January GEOLOGIST with the outline of oscillation ripple-marks given first by De La Beche[‡] and reproduced by Geikie.[§] The wind-formed ripple-mark is of the same class as that formed by a constant current in water, but the new element imposes important modifications. On account of the buoyancy of the water a current of given strength is much more effective than a similar current in air, and so it produces ridges of greater hight and separation, and of coarser material. In rivers, moreover, the direction and velocity of the current are constant for long periods of time, and so the structures are not confused and cross-bedded by shifting currents. Again, the water between the sand-grains acts as a cement, and the sand consequently becomes so firm that the march of the completely formed ridge is very slow. Finally, the water is the carrier of large quantities of sediment, which it deposits wherever opportunity offers, and thus the material found composing ripple-marks in rivers is not usually that in which the ripple-mark series began. The constancy of the current does not give rise to those incessant vacillations in position of the vortexes which occur in the oscillation ripple-mark, and, at greater intervals, in the wind-blown sand; hence the successive layers, particularly if the deposition be rapid, are ordinarily conformable, except that each new layer moves slightly forward, in a direction parallel with that of the current. We may have ripple-marks of this class in mixed material by two processes. First, if a strong current produce ripple-marks in homogeneous sand these will be high and broad, and coarser material, brought by the stream, may lodge in the sheltered places without interfering with the structure. It is to be noted that a loose pebble of considerable size may be more easily moved by the current than the smooth bed of firmly packed sand, so arranged as to present the greatest possible resistance to the current. Second, if the strength of the vortex be sufficient to move coarse gravel and even pebbles it is evident that the ripple-marking process will go on in mixed material quite as well as in sand, which is more uniformly finely divided. The strength of the vortex will depend upon the strength of the current. So it is quite possible that a ridged structure analogous to ripple-marking may be produced in beds which are entirely of pebbles, in swift rivers.

"Finally," says the writer of the foregoing communication, "could ripple-mark exist at all in a current of sufficient velocity to 'sweep along pebbles the size of an egg'? A current of less than one-half this velocity is quoted by Lyell as sufficient to 'tear up fine gravel.' In such case a current flowing two miles an hour would certainly tear up fine sand." In single-current ripple-marks, unless both the current and the resulting vortex are strong enough to move the sand, it seems clear that the sand will not be moved, and no ripple-mark will be formed. It will appear quite clear, moreover, from a consideration of the cause of their formation, that the more exposed portions of these ridges do not bear the pressure of the bottom velocity of the stream, for they lie in a comparatively quiet zone, where the force of the direct current is to a great extent counteracted by the current of the vortex.

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[*] Principles of Geology, p. 343.

The Geological Observer, p. 87 (1851).

[†] Text-book of Geology, p. 335.

[‡] Op. cit., p. 508.

[§] Op. cit., p. 507.

At Cloquet, Carlton county, Minnesota, the writer, while in company with Mr. Warren Upham, observed a cut in a bed of glacial sand which had exactly the same features as those of the most sandy portions of the cut near Iron Junction. The following is an extract from notes made Oct. 21, 1893: "In the horizontal layers of one of the deposits near the town, on the west side of the river, a ripple-marked structure exactly like that south of Iron Junction was seen. The material, however, was of homogeneous fine sand, which did not so accentuate the steeply-inclined line of growth following the apexes of the ripple-marks." Very near this cut the St. Louis river flows, and the direction of the current indicated by the ripple-marked sand is nearly that of the present stream.

Mr. Upham has shown me a photograph, taken by Prof. W. O. Crosby at Mt. Hope, a few miles southwest of Boston, which exhibits a similar ripple-marked structure in a bed of stratified sand. The ripple-marked portion of the section photographed is about 30 feet long and 5 to 6 feet high. The separate layers in the bedding are nearly horizontal in their general course, but are ripple-marked along their whole extent. They are always conformable, crest for crest, and trough for trough, and the thickness through which this extends is five to six feet. In this case the steeply inclined lines connecting corresponding portions of the successive ripple-marks, instead of being straight, follow a gentle curve, which at the bottom begins with an angle of about forty degrees from the horizontal and gradually increases this angle till its course is nearly perpendicular. This curve and the constantly diminishing size of the ridges toward the top of the section point to a gradual slackening of the current. In the photograph about seventy-five distinct ripple-marked layers can be counted.

The writer has observed in various places well-formed ripple-mark in the bed of streams. The case of Embarass river in St. Louis county, Minnesota, is important. This river flows from Esquagama lake, the lowest in the series of the Embarass lakes, and empties into the St. Louis. It thus has a length of less than ten miles, but carries a considerable body of water. In September of 1893 this river was canoed by the writer; and it was observed that the bed of sand and pebbles was almost continuously strongly ripple-marked. At this season the water was so low that the structure could be well observed. Here the writer first saw ripple-marking in places where pebbles were present, and noticed that the pebbles almost always came to rest in the troughs.

The velocity of the current was estimated at about three miles per hour. In the St. Louis and other rivers the same phenomena were observed. While travelling in Nova Scotia, in April, 1893, beautiful single-current ripple-marks were seen at Weymouth. They were on a large scale, so as to be conspicuous at some distance, forming parallel ridges across the shallow bed of a fjord and perpendicular to its shores. The currents in this fjord were governed by the strong tides of the bay of Fundy.

In the article in the January GEOLOGIST, the extent of the layers in the false bedding was stated to be often "ten or twelve feet." Since they make an angle of about forty degrees with the bottom, this means a thickness of about eight feet of sediment, which was deposited while the current and the rate of deposition remained nearly constant. In the cut at Cloquet, there is certainly as much; and in the cut at Mount Hope there is a thickness of 5 to 6 feet at least. But this thickness of sediment, in glacial deposits, does not necessarily imply more than a short time for its formation. Professor Davis* has made this clear in the case of delta sand-plains, showing, by the relation of fore-set to back-set beds, how very swift was the formation of these deltas as compared with the melting back of the ice-front. Again, the formation of kettle-holes by the melting of ice-blocks which had become partly or perhaps sometimes wholly buried in the rapidly accumulating sediments has been discussed by several writers. The melting of these ice-blocks, however, was in its turn so rapid that, according to Mr. J. B. Woodworth, after the subsidence of the waters which deposited the sediments it furnished "streams of considerable volume, though possibly of short duration."†

Feb. 6, 1894. J. E. SPURR.

PERSONAL AND SCIENTIFIC NEWS.

PROF. J. W. SPENCER VISITED CUBA in January, with a view to follow up the question of terrestrial oscillations recently discussed by him before the Geological Society of America.

THE CIRCULAR OF THE CORNELL UNIVERSITY SUMMER SCHOOL for 1894 announces courses by Prof. Ralph S. Tarr on physical geography, dynamical geology, and economic geology.

IN THE TRANSACTIONS OF THE KANSAS ACADEMY OF SCIENCE, at its twenty-fourth and twenty-fifth annual meetings, published in 1893, Prof. S. W. Williston records an interesting food habit of plesiosaurs. In a number of instances well worn siliceous pebbles were found among the ribs of plesiosaurs in such a way as to suggest that they had been in the stomach of the animal. The pebbles were mineralogically unlike any found in the strata in which the saurian skeletons were embedded. All the smaller pebbles were worn smooth and were ellipsoidal in shape. The larger ones showed rounded angles, indicating, as the author says, a less amount of abrasion. Another point of interest lies in the fact that all the pebbles were conspicuous in color, either white, black, or pink. The inference is that the pebbles were purposely swallowed and served as an aid to digestion, and that the plesiosaurs possessed a color sense which led them to select the more conspicuous rock fragments. The distant shores of the Fort Benton and Niobrara seas must have been visited by the reptiles, for only along the shores were such highly indurated masses to be found. Many of the fragments are of red quartzite and must have been derived from the quartzite of the Dakota group or from the horizon of the Sioux quartzite. It is known that ledges of both quartzites were present along the shores of the interior sea in which the plesiosaurs of the Fort Benton and Niobrara ages lived.

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*Bulletin, Geol. Soc. Am., vol. I, p. 199.

†AMERICAN GEOLOGIST, November, 1893, p. 279.

Dr. J. W. Gregory, as rerorted by *Nature* (Jan. 18), in an address before the Royal Geographical Society of London, on his recent explorations in eastern equatorial Africa, described the series of lakes which occupy deep rifts in the country, including lake Tanganyika (350 miles long, 15 to 60 miles wide, 2,700 feet above the sea, and having a depth of more than 1,200 feet), lake Nyassa (300 miles long and averaging 25 miles wide, 1,500 feet above the sea, enclosed by very grand scenery of high mountainous plateaus), lakes Natron, Nawasha, Baringo and Basso Narok (lake Rudolph). From the last of these a line of depression continues northward through Abyssinia into the Red sea; and thence it can be followed along a vast fault from the gulf of Akaba to the Dead sea and Jordan valley. "It seems not unlikely," says Dr. Gregory, "that the whole of this great line is due to one common earth movement of no very great age, for the traditions of the natives around Tanganyika, of the Somalis and Arabs, and of the destruction of Sodom and Gomorrah, may have reference to it." On Mt. Kenia moraines of ancient glaciers were found, 5,000 feet below their present level.

The theory of glacial erosion of lake basins of rock in drift-bearing regions has been very ably revived by Alfred Russel Wallace (*The Fortnightly Review*, Nov. and Dec., 1893). It is now known, however, that deformations of the earth's crust by differential uplifts and subsidences were coincident with the accumulation of the ice-sheets and of the formerly vastly extended glaciers in mountain districts, as the European Alps; so that it remains to be discriminated whether glacial erosion or crustal deformation contributed the principal share in the production of these rock basins.

Dr. Johnston-Lavis, in referring to specimens and microscopic slides showing eozoonal structure in the ejected blocks of Monte Somma, exhibited by him, said that all the criticisms of Eozoon have so far been destructive, no analogous structure having been found in other localities under conditions that could explain the origin of so curious an arrangement of different minerals. These altered limestones from Monte Somma correspond in all details with those of the original Canadian specimens, and, in many cases, on account of their freshness, exhibit some of the pseudo-organic structural details, such as the stolon-tubes, in far greater perfection than does the true so-called Eozoon canadense. He had been working at the subject in conjunction with Mr. J. W. Gregory, F. G. S. *Abs. of Proc. Geol. Soc. Lond. No. 610*, Series of 1892-93.

Sixth Annual Meeting of the Geological Society of America.

[Concluded from page 148 in the February number.]

Further notes of the papers read at this meeting, held Dec. 27–29, 1893, in Boston and Cambridge, Mass., are as follows:

25. *The Shasta-Chico series of the Pacific coast.* J. S. Diller, Washington, D. C. Several measured sections of the Cretaceous were shown and compared with other sections in different parts of the same region. The stratigraphic and faunal continuity of the Shasta-Chico series, composed in California of the Knoxville, Horsetown, and Chico beds, was fully maintained.

26. *The Cretaceous faunas of the Shasta-Chico series.* T. W. Stanton, Washington, D. C. The Cretaceous strata of the Sacramento valley belong to the Chico formation, the Horsetown beds, and the Knoxville beds,—the last two constituting the Shasta formation. Until recently the Chico and the Shasta were supposed to be separated by stratigraphic and faunal breaks that indicated a considerable time hiatus between them. Later studies of the stratigraphy and larger collections of fossils have shown that these two formations are closely related, and the preliminary announcement that they form a continuous series was made by Messrs. Diller and Stanton at the Ottawa meeting of the Geological Society. The past season's field work has strengthened the evidence of the continuity of the faunas. In studying many sections several distinct faunal zones characterized by certain species or associations of species were recognized, but in every case there was a commingling of species near the confines of the different divisions, so that no sharp line of demarcation could be drawn between them.

27. *Geology of Indian Territory and Texas adjacent to the Red River.* Robert T. Hill, Washington, D. C. The region is very diversified in later Mesozoic and Cenozoic formations, and is where the distinct features of the diverse Appalachian, southern coastal plain, and Texan regions are differentiated. The Washita division of the Comanche series attains its greatest development here, while the Fredericksburg is represented only by a thin limestone formation. The Denison beds, consisting of the Marietta, North Denison, Paw Paw, and Main Street, represent a littoral ferruginated group which thins out rapidly southward.

The Red river flows in the Dakota sandstone from the Grayson county line eastward to Pine Bluff, and this formation is highly glauconitic and abounds in fossil plants. Its easternmost outcrop is in the southwest edge of Arkansas, near the Choctaw line. The two chalk beds of the Upper Cretaceous, presenting a singular coincidence with the Upper and Lower Chalk of Europe, occur in northeastern Texas and southwestern Arkansas. The glauconitic division, synchronous with the Montana, but of the New Jersey facies, was shown to be well developed in northeastern Texas, occurring there and in Arkansas mostly as inliers in the Eocene area, being exposed by erosion. The Neocene and Pleistocene history of the region shows that it has been the scene of similar events to those of the Potomac estuary.

A fauna was announced as occurring in the Shoal Creek limestone of Austin, which is entirely unique and new to our knowledge of the Cretaceous. The brachiopods of the Comanche, upon the authority of Schuchert, were referred to the genus *Kingena*, which had not been hitherto reported in this country. The differentiation and variation of the formations away from this region were discussed at length. The old historic localities were described, and the speaker stated that Mr. Jules Marcou's descriptions of the fossils from Preston and Fort Washita contained the first announcement of the Lower Cretaceous age of beds that constitute a part of the Comanche series.

28. Notes on the Geology of Lower California. S. F. Emmons and G. P. Merrill, both of Washington, D. C. (Read by title.) So little is actually known with regard to the geology of the peninsula of Lower California that the writers feel justified in putting on record the somewhat incomplete data gathered by them in the years 1892 and 1893 with regard to a belt of country some 60 miles in width extending nearly across the peninsula near the 30th parallel of latitude.

Prof. Gabb in 1867 made a reconnoissance trip from the southern end of the peninsula to San Diego, and as a result of his observations divided the peninsula into three topographical provinces: (1) a mountainous portion in the extreme south, consisting of irregular ranges of granitic rocks with a maximum elevation of about 5,000 feet; (2) an intermediate mesa region, with an average elevation of not over 3,000 to 4,000 feet, comprising the greater portion of the peninsula; and (3) a northern mountainous portion, with a longitudinal mountain chain filling the greater part of the width of the peninsula and extending across the boundary into southern California. The older horizontal beds forming the mesa region he considered as probably of Miocene age, and he recognized Pliocene and post-Pliocene beds resting upon their eroded edges.

W. Lindgren in 1888 examined the northern mountainous portion of the peninsula in the latitude of Todos Santos bay, about 60 miles south of the international boundary. He was struck with its resemblance in orographic structure and in the character of its constituent rocks with the Sierra Nevada, and found that the beds from which fossils of the Chico Cretaceous had been already obtained at Todos Santos bay are a small patch of nearly horizontal sandstones which have been protected from marine degradation by a projecting point of older eruptive rocks. With regard to the latter beds he conjectured that they must be more fully developed further south and that the mesa sandstones, doubtfully assigned by Gabb to the Miocene, would prove on investigation to be Cretaceous.

The observations on which the present paper is based, show that the lower beds of the mesa region on the immediate western coast between the 29th and 30th parallels consist of Chico Cretaceous overlaid by Tejon Eocene, both horizons being defined by characteristic fossils. These beds are practically undisturbed and show no evidence of any extensive orographic movements.

Further north are more recent beds, occupying similar positions along the coast, from which no characteristic fossils were obtained, but which, from their lithological character and the few fossils collected, would appear to correspond to Gabb's mesa sandstones and to be of probable Eocene age. Though not observed in immediate superposition over the Chico-Tejon beds, the general altitude of both series leads to the opinion that no considerable movement could have intervened between the periods of their respective depositions.

The mesa sandstones and possibly also the Chico-Tejon beds once extended entirely across the peninsula, covering all but the highest peaks of preëxisting mountain ranges. Since the emergence of these beds there has been extensive erosion, and during a subsequent subsidence later beds of Pliocene or post-Pliocene age have been deposited in the cañons and interior valleys, and the tops of the plateaus have been baselevelled at a slight angle with the bedding of the older beds. Evidence of recent elevation of the peninsula is found in delta plains and wave-cut terraces along the coast at various elevations, strewn with recent marine shells.

The underlying or buried mountain ranges, as far as shown by erosion, disclose a general structural resemblance to the Peninsula Sierra further north, as described by Lindgren. They consist of a western range formed of porphyries, diabases, diorites and dioritic granites breaking through steeply upturned and highly metamorphosed sedimentary beds, and an eastern range with a short and abrupt descent to the gulf coast, consisting of granite and metamorphic sedimentaries, with broad, elevated, longitudinal valleys separating the two ranges. The strike of the sedimentaries and the trend of the minor orographic features of the ranges appear to run more to the west of north than the general trend of the peninsula.

It is suggested therefore that in the broader features of orographic structure, the Peninsula Sierra is a representative of the Sierra Nevada, set off *en echelon* to the southwest, and gradually passing out into and sinking under the ocean. The present depressions of the Gulf of California and the deserts to the north appear to be representatives of the Great Basin of Nevada, and like that to have been once elevated regions separating the Mesozoic seas of the west from the Gulf of Mexico, thus accounting for the faunal differences in the Cretaceous rocks of California and of Mexico.

29. Origin and classification of the greensands of New Jersey. WILLIAM B. CLARK, Baltimore, Md. (Read in abstract by Prof. W. M. Davis.) This paper embodied a discussion of the conditions under which greensand is formed upon the floor of existing seas and a description of such deposits. The striking resemblance which the New Jersey strata bear to them was pointed out, together with certain physical changes which took place during the period of their deposition. A classification, based upon a study of four type sections across the state, was suggested for the several formations represented, although the older terms were retained as economic equivalents. (The same author somewhat fully discusses this subject in his "Preliminary Report on the Cretaceous and Tertiary formations of New Jersey," forming pages 167–245 in the Annual Report of the Geol. Survey of N. J. for 1892.)

30. Crustal adjustment in the upper Mississippi basin. CHARLES R. KEYES, Des Moines, Iowa. (Read by title.) Attention was called to the fact that throughout the Iowa coal field there exist numerous faults of small throw. Many of these are quite close together and form well marked step-faults. Ordinarily it would be impossible to recognize most of these ruptures and slippings except when disclosed by fortunate excavations. Through the extensive working, however, of comparatively thin beds they are capable to be made out. From a careful examination of the large number of these faults it would appear that the adjustment of the tension in the flat-lying strata of the Mississippi basin is, as in mountainous regions, carried on largely by means of many small slippings rather than a few large ones. Most of the faults observed are of the normal variety, with the hade from 15° to 45°. Illustrations are given of the different types of faults observed.

31. A geological study of lake Mohonk and lake Minnewaska, N. Y. William H. Niles, Boston, Mass. The paper gave the results of the study of the origin of these mountain tarns. It necessarily included the structure of the Shawangunk range, upon the crest of which the lakes are located in rock basins. The relation of the geological structure to the occurrence of the lakes was the leading question under discussion.

32. Geologic relations in the belt from Green pond, New Jersey, to Skunnemunk mountain, New York. N. H. Darton, Washington, D. C. This paper related to a narrow belt of Paleozoic rocks, which occupy a narrow trough in the Archean highlands of New Jersey, and extend northward in Orange county, New York. These rocks comprise limestones, shales, conglomerates, quartzites, and flags, ranging in horizon from the middle Cambrian to middle Devonian. In greater part they are far distant from the main mass of the formations in the region westward. The principal ridges to which the harder members give rise are Bowling Green, Green Pond, Copperas, Kanouse, Bearport, Bellvale, and Skunnemunk mountains. Greenwood lake lies in one of the principal valleys.

Various ages have been assigned to the rocks and much uncertainty has always prevailed regarding their horizons and relations. Mather considered all the conglomerates Oneida in age, the slates Hudson River, and the limestones Lower Silurian. The New Jersey Survey considered the conglomerates and flags Potsdam, the slates Hudson River, and the limestones Lower Silurian. In 1884 Mr. Darton began observations in the region and his discovery of Lower Helderberg fossils in some of the limestones afforded evidence that the associated conglomerates are Oneida in age. These observations were extended by Merrill and Britton, who showed that certain areas of slates about Newfoundland are Devonian and apparently Hamilton in position. In 1871 Prof. D. S. Martin had found Devonian plants in the flags at the south end of Skunnemunk mountain. In 1887 Smock studied the relations in that region, and showed that the conglomerate capping this mountain overlies the flags.

Recently Mr. Walcott has found *Olenellus* in the basal limestones at one point, and Foerste and others have shown the wide extension of middle Cambrian limestones in the northern New Jersey region.

The results of Mr. Darton's studies were shown by a map and a series of cross-sections. It was stated that there is conclusive evidence of a great fault extending along the western side of the belt, and that there are several other faults of greater or less importance. The general structure of the region is synclinal, but there are various minor folds, notably in the region south of Newfoundland.

The rocks were classified in a table, of which the following list is an abstract:

Name.	Approximate Age.
Skunnemunk conglomerate.	Middle Devonian.
Bellvale flagstones.	Upper Hamilton (group).
Monroe shales.	Lower Hamilton (group).
Oriskany quartzite and conglomerate.	Oriskany, etc.
Helderberg limestone.	"Lower" Helderberg.
Longwood red shales.	Clinton to Medina.
Green Pond conglomerate and quartzite.	Oneida.
Hudson shales and sandstones.	Hudson "River."
Great unconformity.	Early Ordovician to Cambrian.
Limestone.	Middle Cambrian.
Quartzite and conglomerate.	do. do. ?
Crystalline rocks.	Archean.

Many of the rocks contain distinctive faunas and numerous discoveries of fossils have been made throughout the belt.

Besides the great unconformity there are many overlaps and local unconformities of considerable extent, of which the greatest is at the base of the Green Pond conglomerate.

The Skunnemunk conglomerate caps the double summit of Skunnemunk mountain and extends along the western side of Bellvale and Bearport mountains. The Bellvale flagstones constitute the greater part of Skunnemunk mountain, the northern and eastern portions of Bellvale and Bearport mountain, and the region about Clinton Falls. Along the western side of Bearport mountain they are in greater part cut out by the fault above mentioned. The Monroe shales extend along the slopes and valleys adjoining the ridges of Bellvale flags, and southward up the Longwood valley. They are everywhere very fossiliferous.

The Oriskany quartzites and white conglomerates occur in limited areas, but are exposed at many points from the Longwood valley to the vicinity of Cornwall station, New York. The Helderberg limestone occurs with the Oriskany and contains typical fossils. It is nearly everywhere underlain by the Longwood red shales.

The Green Pond conglomerate constitutes Green Pond, Copperas, Kanouse and Bowling Green mountains in New Jersey and the two Pine hills in New York. As it overlies the Hudson shales, and is intimately associated with the red shales and Helderberg limestone, in conformable sequence, there is no doubt as to its Upper Silurian horizon.

The Hudson formation occurs in very restricted areas within this belt, but covers a wide area to the northwest in Orange county. It lies unconformably on the Cambrian limestones. These limestones underlie a considerable portion of the belt and outcrop at many points along its margin. Their erosion gave rise to the basin in which the formations of the belt were deposited. As has long been known, the limestones are underlain by a quartzite and conglomerate at the head of Macopin pond in New Jersey.

33. *A prismatic stadia telescope.* ROBERT H. RICHARDS, Boston, Mass. (Introduced by Prof. W. H. Niles.) This instrument may be used for measuring distances from the hand or from a tripod. From the hand comparatively short distances only can be measured, with self-reading target, 400 feet; tape target, 1,000 feet. From a tripod, 2,000, 3000 and even 5,000 feet may be measured, according to the magnifying power of the telescope, with an error not exceeding 0.1 per cent., and if the mean of several observations is taken, with an error probably not exceeding .04 per cent.

34. *Ancient volcanic rocks along the eastern border of North America.* GEORGE H. WILLIAMS, Baltimore, Md. The occurrence of ancient volcanic rocks at various horizons along the Appalachian belt has long been recognized by some American geologists. It was the object of this paper to direct attention to many newly discovered areas of this character, as well as to summarize and co-ordinate all pre-existing information on the subject. For this purpose the views held in other countries regarding volcanoes were stated, and the frequent misinterpretation of such rocks in this country was mentioned. The criteria for the recognition of ancient and altered volcanic materials were then given, including the features which distinguish them from other igneous, as well as from sedimentary rocks. All existing knowledge regarding the occurrence of such rocks in eastern North America was then summarized, beginning with Newfoundland and passing southwest. This summary is based upon: 1, published literature; 2, unpublished notes or observations by others; 3, extended personal observations by the writer. It is hoped that a definite formulation of the problem in

its present state may stimulate further interest in the differentiation of ancient volcanic rocks from the other igneous and more or less metamorphosed sedimentary formations with which they are associated in the crystalline belt of the Appalachian system. (This paper is published in full in *The Journal of Geology*, vol. II, pp. 1–31, with map, Jan.–Feb., 1894.)

35. Ancient eruptive rocks in the White Mountains. C. H. HITCHCOCK, Hanover, N. H. In his report upon the Geology of New Hampshire, the author had described the granitic areas as built up of a series of eruptive rocks disposed much like sedimentary terranes. Resting upon a crystalline floor was the foundation called *Conway granite*, a coarse, well-defined, often reddish-colored granite, sometimes 1,000 feet thick. It seems to lie in great sheets dipping slightly in anticlinal fashion. This is covered by the *Albany granite*, a porphyritic rock with abundant feldspar, disposed usually like the older underlying rock and sometimes fully as thick. It occurs also in large veins. Above this comes the *Chocorua granite*, or syenite, in which the feldspar is still more abundant. This is capped by porphyry; and that by a breccia of slate and porphyry fragments, to which the name of *Pequawket breccia* had been applied. The principle of this association had not been stated.

The writings of Judd, Allport and other English geologists maintain that in Great Britain there is an association of granitic rocks similar to that just mentioned. In both areas one might climb a mountain, walking successively upon the several granites, and finding the breccia at the top. Ben Nevis in Scotland is an illustration of these phenomena in Britain. The English authors regard these rocks as parts of one great system of volcanic ejection.

The same and other authors find a corresponding order of succession in modern volcanic rocks. At the base is a granitic core, and at the summit glassy and basic rocks. Owing to denudation, most of the glassy rocks would have disappeared from the Paleozoic volcanoes, but some of them might remain somewhat altered, as felsite and porphyry.

Professor Hitchcock stated that this principle explains perfectly the way in which these granitic rocks are associated in the White Mountains, and also makes unnecessary the dictum of Sorby that granites were formed at a depth of 40,000 feet. The whole series may be found in a vertical section of from 3,000 to 5,000 feet. From the summits of granitic cones like Mt. Ascutney and the Stratford peaks the higher rocks have been removed by erosion; but traces of them may remain, as the felsite upon the smaller adjacent cone of Little Ascutney. The application of this principle of association will be of the highest importance in the understanding of our ancient granites.

36. The chemical equivalence of crystalline and sedimentary rocks. G. K. GILBERT, Washington, D. C. This paper gave the results of the combination of many analyses of the crystalline rocks and certain deductions therefrom concerning the totals of geologic erosion and deposition. Prof. F. W. Clarke took all the analyses of crystalline rocks that were available (in total 880) and combined them, after carefully studying their comparative value. (Bulletin No. 78, U. S. Geol. Survey, 1891, pp. 34–42.) His average of these analyses of the crystalline rocks is presented in the following table of percentages: Oxygen, 47.3; silicon, 27.2; aluminium, 7.8; iron, 5.5; calcium, 3.8; magnesium, 2.7; potassium, 2.4; sodium, 2.4; total, 99 per cent.

Mr. Gilbert then said that, assuming the sedimentary rocks to have been supplied by erosion from the crystallines, we obtain a method of estimating how much sedimentary rock has been formed and the proportions of the different kinds. The aluminium was nearly all deposited in shales, together with some of the silicon. The remainder of the silicon was mostly laid down in sandstones. The calcium and magnesium are in the limestones. The sodium is in the ocean. The iron is not concentrated in any one place, but is diffused generally through nearly all the sedimentary rocks. The potassium is not easy to find; it passed into the ocean, and some of it occurs in glauconite and in the terrigenous deposits of blue mud dredged and mapped in the soundings of the Challenger expedition. Probably it exists in shales, but we need more analyses to determine this. The shales are the residuum after the sandstones and limestones have been segregated. A computation of the relative amounts of sandstones, shales and limestones, based upon the total mean of the analyses of the crystalline rocks, is as follows:

Table of proportions of the sedimentary rocks.

Sandstones, 39 per cent., or about two-fifths.
Shales, 42 per cent., or again about two-fifths.
Limestones, 19 per cent., or about one-fifth.

The sodium in the ocean is a definite amount and equals a layer of sodium 350 feet deep on the land, which corresponds to one mile of crystalline rock. From this the author concludes that somewhat more than a mile in thickness of crystalline rocks upon areas equal to all the present land of the globe must have been worked over to give our sedimentary rocks.

37. *Volcanite, an anorthoclase augite rock chemically like the dacites.* WILLIAM H. HOBBS, Madison, Wis. (Read by Prof. G. H. Williams.) A petrographic study of the "bread crust bombs" from the eruption of Volcano in 1888. The rock of these projectiles is mineralogically a trachyte, with anorthoclase replacing sanidine. The structure is andesitic and chemically the rock is a dacite. It contains interesting magmatic pseudomorphs after augite phenocrysts.

38. *Further notes on the occurrence of Albertite in New Brunswick, Canada.* H. P. H. BRUMELL, Ottawa, Canada. (Read by title.) Description of several interesting specimens illustrating peculiar conditions of the mineral in rocks at the base of the Albert series, Albert county, N. B.

39. *Alterations of silicates in gneiss at Worcester, Mass.* HOMER T. FULLER, Worcester, Mass. In a quarry of gneiss in which orthoclase largely predominates are found veins and geodic cavities filled with calcite, stilbite, prehnite, and chabazite. The process of formation of the last three was described and illustrated in this paper. Bosses of hornblende and biotite are also found partly changed to chlorite, and this alteration was explained.

40. *Pre-paleozoic decay of crystalline rocks north of lake Huron.* ROBERT BELL, Ottawa, Canada. An eroded surface of granite occurs under limestone of the Black River formation in the North Channel of lake Huron. Rounded pits in the surface of the granite are filled with fossiliferous limestone and sandstone. Caverns, called "ovens," indent steep slopes and bluffs of the granite. Old channels along joints in granite and other rocks were deepened by glaciation. Rough, unglaciated surfaces of Huronian quartzite are shown to have been formerly covered by Trenton limestone. These features, and also decay in ancient geological times of greenstone dikes cutting the Huronian and Laurentian rocks, and the disposal of the detritus from the old crystalline surface, were treated in this paper and illustrated by photographs.

41. *Gabbros on the western shore of lake Champlain.* JAMES F. KEMP, New York City. The paper opened with a brief statement of the general geological relations in the area described. Although in many respects obscure, disguised by metamorphism, and concealed by drift or forest growth, the succession is probably the following, from earliest to latest: a series of gneisses, composed of orthoclase (mostly microperthitic), quartz, and mica or hornblende or augite; a series consisting of black hornblende and pyroxenic schists or gneisses, of crys-

talline limestones, and ophicalcites. Next in age, penetrating both these, is found the great series of igneous rocks of the gabbro family, which chiefly make up the Adirondacks. Still later are the Paleozoic sediments, of which the Potsdam is the oldest.

The gabbros were shown to include nearly pure aggregates of labradorite at one extreme, which were called anorthosites in accordance with Prof. F. D. Adams' precedent, and quite basic olivine-gabbros at the other extreme. Between these two almost every gradation is met, but the anorthosites favor the main mountain masses, while the basic gabbros occur more as outliers. All exhibit most remarkable effects of dynamic metamorphism, such as crushing and brecciation, development of gneissoid structure, change of pyroxene to hornblende, etc. Remarkable reaction-rims that surround olivine, pyroxene and titaniferous magnetite, where coming next to feldspar, were especially dwelt on, and the parallels occurring elsewhere were cited. Quite extended mention was also made of the contact phenomena where the gabbros penetrate the limestones. The paper concluded with a brief review of the other known gabbro areas in North America, and especially of the Canadian exposures described by Prof. Adams, with whose Morin district the Adirondacks stand in very close relations. Acknowledgments were made to Prof. James Hall, state geologist, and Dr. F. J. H. Merrill, director of the N. Y. State Museum, for permission to use the materials which were chiefly gathered under their direction.

42. Notes on the occurrence of mica in the Laurentian of the Ottawa district. ROBERT W. ELLS, Ottawa, Canada. (Read by title.) A brief discussion of the geological relations of the Laurentian rocks, with description of certain peculiarities as to their occurrence, observed in the townships of Hull, Wakefield and Templeton, and at points along the Gatineau and Du Lievre rivers.

43. Intrusive sandstone dikes in granite. WHITMAN CROSS, Washington, D. C. (Read by title.) In the area of the Pike's Peak granite mass, in Colorado, there occur sandstone bodies whose *formal* relations to the granite are perfectly analogous to those of dikes of igneous rock, while the *substance* of the masses in question is purely a clastic mixture, almost wholly of quartz, of fine and even grain, very smiliar to sandstones of sedimentary origin. These rocks and their occurrence were described and illustrated by hand specimens.

44. Age of the Auriferous slates of the Sierra Nevada. JAMES P. SMITH, Palo Alto, Cal. The Auriferous slates have been assigned to various ages, ranging from Paleozoic to Cretaceous. The various known localities for fossils in these slates are discussed, their horizons are determined, and new information is added about certain Carboniferous, Triassic, and Jurassic localities. The Mariposa slates are ascertained by paleontologic evidence to be of upper Jurassic age, probably lower Kimmeridge. The *Aucella*-bearing beds of California are discussed, and found, after the analogy of the *Aucella*-bearing beds of Russia, to range from the top of the Oxford, upper Jura, to the Neocomian, lower Cretaceous. Neumayr's theory of climatic zones is shown not to apply with exactness to the Jura of California. The uplift and metamorphism of the Sierras and Coast range are thought to have taken place in late Jurassic time.

45. Origin of the coarsely crystalline vein granites or pegmatites. WILLIAM O. CROSBY, Boston, Mass. The leading idea of this paper is that the pegmatites or giant granites are the product of neither solution (veins) nor fusion (dikes), but of the more perfect co-operation of heat and water in what may be called aqueo-igneous fusion and igneo-aqueous solution. We may assume that, whatever may be true of other igneous rocks, water has contributed to the liquefaction of the micaceous granites, with which the pegmatites are so generally associated. During the extremely slow, centripetal cooling and solidification of a body of granite magma, at a great depth in the earth, the water in the magma is gradually forced inward, the magma residuum becoming thus more highly hydrated and more liquid. Fusion passes without a break into solution; and the increasing mobility of the unsolidified magma finally permits the development of the coarse and perfect crystallization, comb-structure, vugs or pockets, and other characteristic features of typical pegmatite. Pegmatite may thus be defined as a highly differentiated portion of a granite magma, the water, which is an essential feature of the magma, becoming concentrated in a limited portion during solidification. The amount of water being quite insufficient to hold the minerals of the magma in simple solution, they crystallize out long before the magma reaches that condition.

Soret's principle, upon which Iddings bases his argument for the general differentiation of igneous rocks, that if the temperature of a solution is not uniform the dissolved substances will become concentrated in the cooler part of the solution, also finds application here. The cooler part of a body of magma is the periphery, and toward this the dissolved minerals are concentrated, the central and hotter portion of the magma or solution thus becoming steadily thinner—poorer in dissolved minerals and richer in the solvent (water)—until at last the conditions favor the coarse and perfect crystallization of the pegmatites. Spherulites and lithophysæ are believed to present analogous phenomena on a minute scale; and an instructive analogy may also be traced between the development of pegmatite masses with pockets in the center of a granite boss and the formation of an ordinary quartz geode, with its characteristic chalcedonic shell, crystalline interior, and central pocket. The pegmatites are intermediate, in origin, between plutonic or dike rocks and vein rocks, combining the characters of both; and the author holds that the true veins are entitled to recognition in the lithological classification.

46. *A classification of economic geological products, based upon origin and original structure.* WILLIAM O. CROSBY, Boston, Mass. This paper will be presented in full in an early number of the AMERICAN GEOLOGIST.

47. *Lake Cayuga a rock basin.* R. S. TARR, Ithaca, N.Y. (Read by title.) After reviewing the literature relating to the origin of the Finger lakes of central New York, evidence is presented to show that lake Cayuga, having a maximum depth of 435 feet, is in a rock basin. This evidence is obtained from a study of the preglacial tributaries, which at present empty into the lake in completely enclosed rock valleys whose rock bottoms are above the present lake surface. Lake Cayuga is therefore in a preglacial valley, which has been deepened during the Glacial period at least 450 feet at one point.

Evidence is also presented to show that the preglacial Cayuga river flowed northward, being tributary to the preglacial Ontario stream. It seems accordingly an inevitable conclusion that lake Ontario is also a rock basin. The conclusion is thus reached that no evidence is afforded here in favor of continental elevation and depression; and it is also pointed out that, this being the case, an outlet for the preglacial great lake basin drainage through the Mohawk and Hudson is more probable than it has hitherto appeared.

48. *Pleistocene problems in Missouri.* JAMES E. TODD, Vermillion, S. D. (Read by Mr. L. S. Griswold.) This paper presented some of the data recently collected by the author in exploration for the Missouri Geological Survey, and attempted to harmonize them with similar facts from adjacent regions. The data comprise descriptions of the preglacial deposits; of the character and distribution of the bouldery drift, or till, and of the loess and its associated deposits; of the terraces, ancient channels and rapids of the Missouri and other streams; and of the present topography as related to the Pleistocene formations. The

problems are to determine whether the till was mainly of subglacial origin; how much of the drift was of lacustrine and glacio-natant origin; and to what extent the Pleistocene deposits of northern Missouri may be ascribed to flooded rivers.

49. *Remarks upon a supposed glaciated stone axe from Indiana.* G. FREDERICK WRIGHT, Oberlin, Ohio. The glaciated stone axe described by Mr. John T. Campbell in Science, vol. xxi, p. 346, for June 23, 1893, was exhibited to the Society and commented upon by Profs. Wright, Niles, Hyatt and others. The general conclusion was that it was a glaciated stone of such shape as to be readily utilized by the artificer, and that it had not been glaciated since the manufacture.

50. *Pseudo-cols.* T. C. CHAMBERLIN, Chicago, Ill. The theme of this paper is closely connected with the next, in the discussion of probable changes, effected during the Glacial period, in the courses of drainage of the upper Ohio, Allegheny, and Monongahela rivers. The French term *col* is gradually coming into use to signify low passes or saddles on the watershed between drainage systems. Its use is very convenient in the discussion of reversed or diverted drainage, particularly that caused by the intrusion of glacial or igneous obstacles. It not infrequently happens that, when a glacier enters the lower part of a drainage basin, it ponds back the waters, and causes them to pass over such a col into a neighboring basin. Sometimes the valley becomes permanently filled with glacial wash and morainic débris to such an extent as to cause the diverted stream to retain its new course after the retreat of the ice. In such cases the stream, in subsequently deepening its valley, forms a trench across the col, which gradually takes on the form of an ordinary valley. In time the col is only represented by a constriction of the new valley and by certain residual features of the old topographic configuration. The floor of the trench across the col obviously assumes the slope of the new stream that caused it and has its highest part on the up-stream side of the former col. As the trench is cut deeper and deeper, the highest point in the rock floor is gradually carried up stream. It may, in this way, be transferred some distance from the original col and may thus become entirely disassociated from its peculiar topographic relations.

If, after this has been done, another glacial invasion ensues and the valley becomes again filled with glacial wash to some considerable hight, the transferred summit of the rock floor is liable to lose its obvious connection with the old col and may perhaps seem to be associated with new and misleading topographic surroundings. In such a case, if the valley debris is penetrated by wells at only a few points and the investigator ascertains thereby only imperfectly the nature of the trench and the location of the rock summit in its buried floor, he is liable to mistake this obscured rock summit for a true col. It is, in fact, not a col at all in any proper sense. It never has been a watershed, and has never performed the functions or sustained the relations of a true col. As there is frequent occasion to refer to this phenomenon in the discussion of certain regions of reversed drainage along the border of the ancient glacial formations, I propose for it the distinctive name *pseudo-col.* The nature of the phenomenon has been more or less distinctly recognized by many geologists. The purpose of this paper is merely to bring it forth into more definite recognition, and to supply it with a convenient name, which may be used in lieu of the cumbersome periphrastic phraseology now required.

51. *Certain features of the past drainage systems of the upper Ohio basin.* T. C. CHAMBERLIN and FRANK LEVERETT, both of Chicago, Ill. This paper begins with a discussion of the probable old drainage basins. It supports strongly Mr. Carll's views, advanced some years ago, that the two uppermost sections of the present Allegheny basin, namely, the portion above the Kinzua col and that between the Kinzua

and Thompson cols, formerly discharged northward to the lake Erie basin. A third natural section of the present Allegheny is found between the Thompson col and the mouth of the Clarion river, where a col has apparently been surmounted by the present stream. Evidence amounting almost to a demonstration is found that this portion of the Allegheny had its discharge through a broad and meandering valley following in part the lower course of French creek and in part an abandoned channel to Carll s "Conneaut outlet" and thence into the lake Erie basin. A possible fourth point of division of drainage systems is placed on the Ohio river near New Martinsville, West Virginia, which would throw the lower Allegheny, Monongahela, and upper Ohio rivers into the lake Erie basin through the Beaver and Grand river basins. Concerning reversal of drainage in this section of the upper Ohio, the evidence collected, though suggestive, is considered too incomplete to justify any firm opinion. This hypothesis differs from the one recently advocated by Dr. Foshay in placing the divide some fifty miles farther south, in giving the outlet a slightly different course from the Beaver to the Grand river basin, and in restricting the applicability of the hypothesis to the elevated base plane or to the upper part of the trench cut in it, data concerning the rock floor having been collected by Mr. R. R. Hice which demonstrate its inapplicability to the lower trench.

The transgression of cols and the development of pseudo-cols through shifting of the summit of the rock floor by erosion was briefly touched upon. Some cols have shifted but little, while others may have passed up the river many miles. The supposed col near the mouth of the Clarion is thought to have shifted its pseudo-col about ninety miles to the vicinity of Warren, where it has become coalescent with that of the Thompson col.

The importance of considering each section of the Allegheny by itself was urged, since in preglacial time it had an independent history and even in glacial times differed in some respects from its neighbor.

The glacial drift of the region is separated into two distinct parts: (1) the attenuated border; (2) the series of moraines. The recent studies have shown that the high level gravels of the river valleys have a definite relationship to the attenuated drift, a relationship essentially the same as that of the moraine-headed terraces to the moraine. Since the gravel trains connected with the attenuated drift-sheet stand at altitudes far above the adjacent moraine-headed terraces, the conclusion cannot well be avoided that great erosion occurred between the two gravel depositions. consequently a great break in the glaciation. This being the case, the attenuated drift should no longer, in that region at least, be considered a dependency of the moraine which it borders.

Terraces and gravel deposits occur along the Allegheny at levels between the high gravels and the moraine-headed terraces, but they commonly occupy such situations on sloping points, etc., as would be favorable to deposition during the progress of valley cutting as well as during valley filling. As such they do not furnish decisive evidence as to whether they are remnants of early gravel, or of the possible valley filling between the early and late gravels, or are incidents of valley cutting. In the lower Allegheny region no place was found, after careful search, where abandoned ox-bows or deep recesses of the valley contain a filling of early gravels comparable in depth to the present trench. On the upper portions of the Allegheny which were interpreted to have led directly to the Erie basin the broad preglacial base planes lie nearly as low as the present streams and trenching is not carried far below them. The small amount of trenching there strengthens the negative evidence against deep *preglacial* trenching on the lower Allegheny.

In interpreting the phenomena of this region the hypothesis of a single continuous glaciation is necessarily excluded because of the great erosion which occurred between the depositions of the two or more systems of glacial gravel. Four hypotheses relative to the history of the phenomena were introduced, three of which postulate but a single interglacial epoch, and one of which postulates two interglacial epochs. Computed ratios of work done in each of the stages of filling and of excavation under each of the several hypotheses were presented. The amount of valley filling associated with the terminal moraines (i. e. the valley filling of the last glacial epoch) was taken as the unit of comparison for valley filling, and the amount of postglacial excavation of the gravels was taken as the unit of excavation. The amount of valley filling of the earlier glacial epoch under the four hypotheses ranged from two and two-thirds to seven times that of the last glacial epoch. The amount of valley excavation in the interglacial epoch under each of the three hypotheses which postulated one such epoch was thirteen times the postglacial excavation; in the remaining hypothesis it exceeded thirteen times by an undetermined amount. Attention was directed to the fact that, to the extent to which we assume preglacial excavation of the Allegheny gorge, to that extent we magnify the valley filling of the early glacial epoch. The import of all these hypotheses is alike on most of the vital points relative to the history of the region. They all greatly emphasize the importance and significance of the first glacial epoch. They all show very important intervening excavation, when compared with the erosion which has taken place since the Glacial period. They all indicate that, while the last great glacial invasion was very much more pronounced in its apparent effect, and in the expression which it took on, it was after all but a small factor of the total accomplishment of the Glacial period.

Prof. I. C. White, in discussion of this paper, thought that no sufficient evidence is adduced for any of these lines of northerly drainage from the upper Ohio basin. He is familiar with nearly the whole area, and thinks that the high rocky rim facing lake Erie is continuous. He had not been able to find any interruption in it sufficient to furnish a channel for the supposed outlet. Besides, he had found, while conducting the survey of the region in the Susquehanna valley near the terminal moraine, that there is the same northerly descent of the bed of that river north of the moraine, but no one supposes that the Susquehanna ever ran to the north from that line. His conclusion, therefore, was that the differential depression to the north was a consequence of the Champlain subsidence, from which the land has only partially recovered. He was inclined also to believe that the weight of the glacial débris accumulated in exceptional amount over the belt immediately north of the moraine is a partial explanation of the remaining northerly depression.

Prof. G. F. Wright suggested that, in the recession of the waterfalls which doubtless characterized the region during the formation of the rock gorge, the beds of the streams may have been eroded to very unequal depths, as is the case now below Niagara, where in the gorge the rock bottom is 200 feet or more below the general surface, while from Lewiston to lake Ontario there can be no such depth. He cited a similar instance in Snake river, Idaho, just above Shoshone falls, where the depth of the river below the general level suddenly increases from a few feet to 100 feet or more.

52. *Glacial History of western Pennsylvania.* G. Frederick Wright, Oberlin, Ohio. The author presented the facts observed near Warren, Pa., by Mr. Leverett and himself in company, which show that the rock bottom in the valleys of the Allegheny and its tributaries at that point was nearly at the same depth before the earliest ice invasion as now. A continuous bank of clearly stratified gravel containing granite pebbles rises from the flood-plain of the Conewango to the level of the 250 feet rock shelf, which was part of the river bed in later Ter-

tiary times, and spreads out over it. This is unquestionably in the area of the earliest drift, hence the rock gorge must be entirely preglacial. On the south side of the Allegheny at Clarendon, four miles from Warren, there are extensive gravel deposits, with granitic pebbles, rising to about the same hight with the terrace described on the Conewango, and filling a buried channel 250 feet deep. This is on the watershed between the Allegheny and the Tionesta. This rock gorge must be wholly preglacial, yet it extends down very closely to the level of that of the present Allegheny. Such an amount of preglacial erosion there would be inconsistent with a less amount anywhere down the Allegheny and Ohio.

According to Prof. Wright, the amount of glacial gravel preserved on the 200 to 250 feet rock shelves of the Allegheny and upper Ohio has not been at all appreciated until within the past year. These gravel accumulations line the gorge throughout nearly its whole length and are often a half mile wide and 50 feet deep. Assuming it to be proved that the erosion of the rock gorge was preglacial, the whole valley must have been afterward filled with gravel derived from the ice-sheet and then re-excavated. Both these processes were probably aided by the Cincinnati ice dam formed by the advance of the ice-sheet there across the Ohio valley, which, by producing slack water as far up as Oil City, retained all the early glacial sediment and so hastened the filling. Later the removal of the ice dam gave an increased gradient to the stream, so that its re-excavation was greatly hastened. While, therefore, not questioning Prof. Chamberlin's estimate of the amount of material eroded since the filling up of the gorge, the time supposed is less because the material was all loose and the gradient much larger than now, while also the glacial floods still supplied a larger flow of water.

53. *The ancient strait at Nipissing.* F. B. TAYLOR, Fort Wayne, Ind. (Read by title.) The following facts relating to the shore lines of the postglacial submergence in the vicinity of lake Nipissing, Ontario, were gathered by explorations during the past season. On the hills north of North Bay four distinct beaches were found. Measured by aneroid from North Bay station, which by the C. P. R. profile and Dr. J. W. Spencer's table of altitudes in Canada is 658 feet above mean tide in the Gulf of St. Lawrence, their altitudes are about as follows: 1. Nipissing beach, 743 feet. 2. Thibeault beach, 1,005 feet. 3. McEwen beach, 1,090 feet. 4. Nelson beach, 1,140 feet. The Nipissing beach marks the level of the Great Lakes during the time of the active river outlet eastward down the Mattawa to the Ottawa. This beach is developed in great strength and was seen at many points westward as far as Duluth, Minn. It rises slightly from west to east. The other three beaches are distinct ridges of rounded gravel facing lake Nipissing. The Nelson beach marks the upper limit of submergence. No evidence of submergence was found on higher ground there, but on the hills southeast of North Bay the shore line was found at about 1,205 feet near Sundridge and about 1,220 feet near South river.

About 125 miles west of North Bay heavy gravel deltas of the Ohnaping river and streams flowing into Windy lake were found near the top of the grade eight miles east of Cartier on the C. P. R. at an altitude of about 1,200 feet.

These facts point to the following conclusions: 1. That the upper three of the great lakes tributary to the St. Lawrence had a river outlet eastward across the Nipissing pass for a considerable time; 2. That there was before that time a strait over the Nipissing pass about 25 miles wide and more than 500 feet deep; 3. The observations near Cartier prove a wide extent of water in that direction. Hypothetical extension of the plane of the Nelson beach and Ohnaping delta northward over low lands suggests another strait over lakes Tamagaming and Temiscamang, and over the hight of land and lake Abittibi to the basin of Hudson bay, making the high ground north of lake Nipissing an island. The belief was expressed that these straits connected the great Laurentian lakes with the sea. Two maps accompanied the paper.

54. *Extra-moraine drift between the Delaware and the Schuylkill.* EDWARD H. WILLIAMS, Jr., Bethlehem, Pa. The author gave a summary of his observations during the past year, describing the drift deposits, and noting their order and variations as affected by the geological formations. He further considered the geographical conditions during the Glacial period, and the age of the extra-moraine drift with reference to the terminal moraine. All the glacial phenomena of eastern Pennsylvania are regarded as very recent, with no evidence of an interglacial epoch.

Evidence was presented showing that the fringe, or attenuated border of the glacial deposits in this region, extends across the Lehigh river between the South mountain and Blue Ridge to within a few miles of Reading. During a portion of this early advance and retreat of the ice the mouth of the Lehigh was dammed by the glacial barrier, and its drainage was across a col into the Schuylkill by Topton. At Bethlehem the rock bottom of the Lehigh valley is certainly fifty feet below its present bottom and the channel is filled with débris of the earliest glacial advance, showing that on the Lehigh, as on the Allegheny, the preglacial rock erosion had reached its present extent. Many of the glacial pebbles from this area of the earliest ice advance are about as fresh and free from chemical changes due to weathering or leaching as any from north of the moraine. (This subject was also discussed by Prof. Williams in the January number of the American Journal of Science.)

55. *The Interglacial series of Germany.* Prof. Dr. ALFRED JENTZSCH, Königsberg, Prussia. (Read by title.) The International Congress of Geologists at Washington in 1891, in discussing the stratigraphy of Quaternary deposits, reached no agreement on the question of an interglacial epoch in Europe. Some German geologists spoke for the existence of an interglacial epoch, and others against it. Having been in explorations and study of the drift in northern Germany since 1872, I am much interested in this question, and must declare that quite surely northern Germany (with probably the greater part of the drift-bearing region in Europe) has had at least one interglacial epoch, and perhaps two.

There are many difficulties, however, in the investigation of this subject in Germany. Most of our provinces are poor in Pleistocene fossils, and in all the provinces these fossils are mostly found not in their original place, but in their second or third place of deposition; often the bones of great terrestrial mammals are mixed with fluviatile or marine molluscan shells. Our drift deposits have a thickness of 100 to 150 meters (300 to 500 feet), and their stratigraphy is very complicated and variable within small areas. The deepest valleys of northern Germany have cut into the drift not more than 200 feet. We have not only two, but four, five, or more glacial deposits (boulder-clay) at the same locality, separated by stratified beds of gravel, sand and clay. Beds of the same character are often found at very different stratigraphic levels, and they are often disturbed by glacial pressure and other causes. For example, at one place in eastern Prussia we find Cretaceous and Tertiary strata as a mass of 100 feet thickness on an area of 400,000 square feet, resting upon 100 feet of drift deposits, and covered by drift of 100 feet thickness.

Surveying and mapping Prussia on a scale 1:100,000, and in part 1:25,000, and studying several hundred sections of artesian wells, we have found, between glacial boulder-clays, deposits of sands, clays, etc., with an entirely consistent flora or fauna. We know layers of *Ostrea*, of *Mytilus*, of *Cardium*, each of them containing thousands of shells of few species, often with both valves united. We know small Pleistocene beds of lignite, with numerous identifiable plants, indicating a temperate climate, and elsewhere we see, as at Vogelsang, a Pleistocene chalk, filled with fluviatile diatoms and shells, underlying a marine bed filled with *Cardium edule* and *Tellina baltica.* All these beds are situated between two boulder-clays. I am far from saying that each sedimentary bed interposed between boulder-clays indicates an interglacial epoch; for I know, and have demonstrated, that such beds may be formed by subglacial waters. But I propose to take each observation of a consistent fauna or flora in a hundred or thousand specimens as a case of original deposition, and therefore, if it lies between boulder-clays, as a case of interglacial sediments, and if it lies at the base of all known boulder-clays, as a case of preglacial sediments.

In England we have in preglacial time, ending the Tertiary and beginning the Quaternary era, the Forest bed and the Bridlington Crag. Similarly in Prussia there occurs a sandy bed with *Dreissena polymorpha*, *Valvata* species, and the bones of *Elephas*, *Rhinoceras*, *Bos*, *Equus*, and *Cervus tarandus;* and, above that bed, a clay with *Yoldia arctica*, *Cyprina islandica* (small variety), *Astarte borealis*, *Phoca* (*Tagophilus*) *grœnlandicus*, and numerous bones of *Gadus* species. Thus at first there was a fluviatile fauna of Sarmatian character, and then a marine fauna of Spitzbergen character. Next followed the Early Glacial (Altglacial) epoch, depositing a series of boulder-clays, with intercalated gravels, sands and clays, containing few organic remains. The few fossils which we have found here are not consistent, for in these ancient glacial deposits teeth of *Elephas* occur near shells of *Yoldia*, and *Yoldia* is mixed with *Dreissena* or *Valvata*, but neither *Cardium* nor *Tellina*, *Mactra*, *Nassa* nor *Cerithium* are found in the preglacial and ancient glacial strata. The later named species are found only in interglacial and later glacial strata.

The interglacial series is marine near Bremen, Hamburg, Kiel, and in Denmark, also in the greater part of Prussia; but it is fluviatile near Königsberg and Memel, likewise near Berlin, and at Lauenburg on the Elbe. The interglacial marine fauna of Prussia is composed of *Cardium edule*, *C. echinatum*, *Tapes virginica*, *Cyprina islandica* (larger variety), *Tellina baltica*, *Mactra subtruncata*, *Mytilus edulis*, *Scrobicularia piperata*, *Mya* species, *Corbula gibba*, *Nassa reticulata*, *Cerithium* species, *Littorina litorea*, and *Scalaria communis.* Never is *Yoldia arctica* found in these beds, which have yielded many thousand specimens of these more temperate species! All the animals and plants of this series indicate a moderate climate like that of the present time, but perhaps of more insular character.

Then follows the Late Glacial (Jungglacial) series, composed, like the Early Glacial, of boulder-clays, with intercalated gravels, sands and clays. These younger gravels are rich in organic remains, but the fossils are mixed, representing all known preglacial and interglacial beds. Very commonly we find *Yoldia arctica* together with *Cardium*, *Dreissena* and *Elephas*, showing clearly that these fossils must be regarded as derived from older beds.

In conclusion, I think it certain that northern Germany had an interglacial epoch. The same epoch, with terrestrial fossils, is indicated in Great Britain, Switzerland, Austria, northern Italy and along the Rhine. Perhaps we may see proofs of its existence also in some fossiliferous beds found recently near Moscow and in Scandinavia. Accordingly I ask the fellows of the Geological Society of America to give some place to this short communication in forming your theories of the Ice age in Europe.

56. The Madison type of drumlins. WARREN UPHAM, Somerville, Mass. (Read by title.) The Capitol, University and Observatory hills in Madison, Wisconsin, are drumlins of a peculiar class or type, consisting of till on their surface, and mainly to depths of five to ten feet or more, while stratified sand or gravel form their nucleal and greater part. The till is believed to have been englacial, being thence deposited, like a veneer, on unusual subglacial stream accumulations of modified drift. (This paper will be presented in full in a later number of the AMERICAN GEOLOGIST.)

57. *Diversity of the glacial drift along its boundary.* WARREN UPHAM. (Read by title.) Different phases of the drift near its limits across the United States and about the Wisconsin driftless area were considered in relation to the methods of transportation and deposition, ensuing erosion, and sequence in age. Remarking how nearly coincident the earlier and later drift boundaries are for the long distance from the Scioto river in Ohio eastward to the Atlantic coast, the author thinks that they cannot be referred to distinct epochs of glaciation separated by a long interglacial time, as some have supposed, when the ice-sheet made a long retreat to the north or was wholly melted as now from this continent. He believes it more reasonable to appeal instead, as Prof. James D. Dana has recently done (Am. Jour. of Science, Nov., 1893), to meteorological differences between the Mississippi basin and the eastern states, whereby comparatively long glacial retreats and re-advances could take place at the west while in the east the ice-border more steadily remained near the drift boundary.

In New Jersey the manner of transportation and deposition of the early extra-moraine drift is held to be a probable explanation of its uneven distribution, occurring near its limits in patches which have led Prof. R. D. Salisbury to suppose that a long time of denudation intervened between the times of deposition of the early and the late drift. The early accumulation and advance of the ice to its extreme limits gave a comparatively thin ice-sheet with feeble erosive action on much of the outer part of the drift-bearing area. Its drift there was nearly all brought from considerable distances at the north and was deposited in obedience to the currents of the marginal portion of the ice-sheet. Now we have upon many districts of the thick later drift the very remarkable aggregations of the till called drumlins, which appear to have been amassed by convergent currents of the ice-sheet during its retreat (AM. GEOLOGIST, Dec., 1892). Similar selective action of the outflowing early ice advance close to its farthest limits is thought by the author to have amassed that outermost early till in the patches where it is now found, having received little change by later erosion.

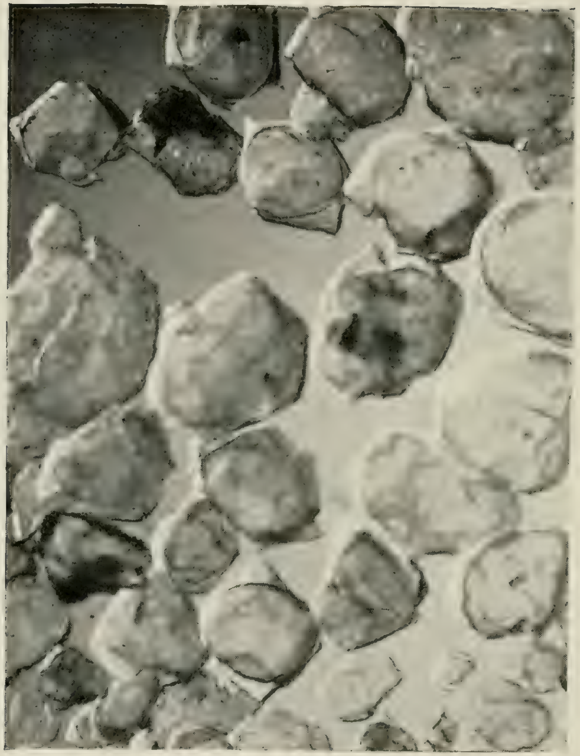
The well oxidized and leached condition of the early outer drift everywhere is easily referred to its derivation chiefly from the preglacial residuary clays, decaying rocks, weathered rock cliffs and tors, and boulders of secular disintegration. Its smoothed surface, without the inequalities of accumulation which provide basins for the myriad lakes and lakelets of the later drift, seems attributable to the gentle currents of the early thin ice-sheet, in contrast with which the later thick ice powerfully eroded its rock bed, even close to the boundary, and tumultuously heaped or very irregularly spread its drift with many lake-enclosing hollows.

58. *Notes on the microscopic structure of siliceous oölite.* E. O. HOVEY, New York City. In the Am. Jour. of Science for Sept., 1890, a siliceous oölite from near State College, Center county, Pennsylvania, was described by Dr. E. H. Barbour and figures were given. That author did not use polarized light in investigating the rock. Some of the same material came into the present writer's hands, and, having been studied between crossed nicols, the details of structure were clearly brought out and were described at length. The spherules, which are very uniform in size and rather evenly distributed through the rock, consist of two distinct zones of minutely fibrous chalcedony deposited about aggregates of very fine-grained quartz sand or fragments of quartz.

Many of the fragments of quartz have been secondarily enlarged by one or two zones of quartz of the same orientation. Sometimes the zone of enlargement roughly approximates a crystal outline. Where there are two zones of enlargement there is a zone of granular quartz between them. The fragments of quartz appear to be of granitic origin. The matrix is of chalcedony, sometimes arranged in one or two rather coarsely fibrous, incomplete, concentric shells around the spherules, sometimes in very minute fibers without apparent orientation, and sometimes in very small spherulites. Granular quartz also occurs in the matrix. No organic remains were observed. The origin of the rock appears to have been a clear quartz sand impregnated by hot siliceous waters. Another siliceous oölite said to be from the Tertiary of New Jersey was described. In this the spherules of chalcedony are very irregular in size and distribution. Many of them are spherulites without an apparent nucleus, while others have grains of quartz in their centers. The paper was illustrated by a drawing of the first oölite between crossed nicols, and a photo-micrograph of the second in ordinary light.

59. *Channels on drumlins, caused by erosion of glacial streams.* GEORGE H. BARTON, Boston, Mass. (Read by title.) Under the direction of Prof. N. S. Shaler, for the U. S. Geological Survey, nearly eighteen hundred drumlins have been studied in Massachusetts and along the southern edge of New Hampshire. Of postglacial erosion there is but little indication, each hill remaining nearly as symmetrical and perfect as it first appeared when finally left uncovered by the retreat of the ice-sheet. Cases of erosion produced in the smooth, flowing outlines of these lenticular masses of till before the ice-sheet had entirely uncovered them are abundant, more than one hundred having been observed. These consist of channels winding down the southern or southeastern slopes of the drumlins. In size they vary from merely incipient depressions to those that are from sixty to one hundred feet in depth. In typical drumlins, having the longer axis parallel with the motion of the ice-sheet, these channels are nearly always parallel with the axis and often coincident with it, cutting directly along the summit of the ridge as it slopes southward. In the more complex masses of till, which often extend in their longer direction nearly at right angles to the glacial motion, they cut down the southern slopes with a direction usually approximately parallel to that of the axes of neighboring typical drumlins. With very few exceptions, there is no cutting down the northern slopes of either the typical drumlins or of the complex groups. In many cases the cutting begins north of the summit but passes directly through it with the bottom of the channel sloping southward continuously from its most northern point.

In origin these channels seem to have nothing in common with the more or less deeply cut valleys between the separate summits of one complex mass. The drumlin contour seems to have been perfectly formed previous to the cutting of the channels. In a few cases direct linear connection is shown between the channels on several separate drumlins, and then usually remnants of eskers occupy the low lands between. This would seem to indicate that the same stream that deposited the esker performed the cutting of the channels. During the early part of the work Prof. Shaler called attention to a channel upon Forbes hill, in Quincy, and suggested the above reason for its origin. Lying upon the southern slopes, with little or no indications of existence on the northern, they must have been formed when the ice had been melted from the south but still lay banked against the northern slopes, by superglacial or englacial streams, which to the northward flowed over icy beds and here were discharged from the front of the ice to plow their way down the southern slopes until they reached the lower levels or plunged into standing sheets of water, as they did in many instances.



Sand grains enlarged, and showing crystalline facets, owing to secondary deposition of silica in optical continuity with the nucleus. From a bed of sandstone two feet in thickness representing the New Richmond sandstone, Allamakee Co., Iowa.

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ON A NEW HORIZON AND SOME NEW LOCALITIES FOR FRIABLE SANDSTONE IN WHICH THE GRAINS ARE ENLARGED BY SECONDARY DEPOSITION OF SILICA IN OPTICAL CONTINUITY WITH THE ORIGINAL NUCLEUS.

By Samuel Calvin, Iowa City.

In northeastern Iowa the last forty or fifty feet of Owen's Lower Magnesian limestone, as it has usually been recognized along the Mississippi river, contains a number of thin beds of sandstone and shale interstratified with the characteristic dolomite. The first or lowest of the sandstone beds varies from two to three feet in thickness. It is more constant than the other arenaceous beds with which it is associated, it is also thicker than most of them, and for these reasons it may probably be regarded as the equivalent in Iowa of the formation that has been called the *New Richmond sandstone* by the geologists of Wisconsin and Minnesota. The beds between the layer of sandstone mentioned and the base of the incoherent, massive sands of the St. Peter, may then be correlated with the Shakopee limestone of N. H. Winchell. McGee, in his memoir on the Pleistocene History of Northeastern Iowa, Eleventh Annual Report, U. S. Geol. Survey, pp. 332-333, unites this upper portion of Owen's Lower Magnesian limestone with the St. Peter, and in the same work proposes to call the great body of dolomite, lying below the horizon of the first intercalated sand bed, the Oneota limestone. The beds in question, however, seem to have more intimate relations with the underlying dolomite than with the St. Peter. Dolomite predominates, the thin beds of sandstones being wholly subordinate in importance. For probably more than ninety-five per cent. of the time required for the deposition of these beds, the conditions were essentially the same as prevailed during the preceding time, when dolomite was deposited without interruption. If, therefore, in Iowa, different formational names are not to be applied to the strata in this portion of the geological column, some name, coextensive with Owen's Lower Magnesian limestone, must be locally employed to embrace all the dolomitic beds, together with the few thin beds of intercalated sandstone, lying between the top of the St. Croix series and the base of the massive, friable, quartzose deposits that beyond question belong to the St. Peter sandstone. In this great body of sediments we have a record of continuous deposition under practically similar conditions, these conditions being only temporarily interrupted by the deposition of thin beds of sandstone in the last forty or fifty feet of the formation. For the present I am disposed to extend the application of McGee's name, and locally, so far as Iowa is concerned, call this whole assemblage of strata the *Oneota limestone.*

This discussion seemed necessary to fix definitely the horizon of the sandstone to which reference is made in the title of this paper; for it is the siliceous bed, two or three feet in thickness, forty or fifty feet below the top of the Oneota formation as here defined, and probably the equivalent of the New Richmond sandstone of Minnesota and Wisconsin, that is to be considered. This sandstone is quite constant over a large area in the northeastern half of Allamakee county. Fragments of it are strewn in all the washes and waterways that cut below the level at which it lies. It breaks into prismatic blocks which, notwithstanding the fact that it is easily friable, retain their form unusually well when compared with masses of sandstone derived from other sources. Its fragments are at once distinguished by certain peculiarities of appearance from all other blocks of sandstone with which they may be accidentally mingled. It looks sometimes as if they were partially vitrified, or rather they suggest the appearance of blocks of porous sandstone saturated with some transparent non-volatile fluid. In the sunshine the freshly broken surfaces sparkle and glitter with numberless shining points, as the light is reflected from myriads of minute crystalline facets. Small fragments of the sandstone may be crumbled between the fingers. If the detached grains are placed on a black surface and examined with a good magnifier their crytalline character becomes apparent, and the angles and faces may be made out fairly well. Examined with a compound microscope having a low power objective, the crystalline angles and facets can be more satisfactorily determined. Mounted in balsam and viewed by transmitted light, the boundary between the original sand grains and the chemically deposited envelope becomes in all cases apparent, on account of the thin layer of ferric oxide with which the grains were originally coated. With polarized light the optical continuity of nucleus and envelope is readily demonstrated.

The localities in Allamakee county, Iowa, where this crystallized sandstone is exposed are very numerous. It may be seen in place by the side of the road in the S. W. $\frac{1}{4}$ of Sec. 26, T. 98, R. 5 W., about three miles east of Waukon, and blocks of it are strewn for a mile or two down the valley that leads toward Village creek. In the valley of Waterloo creek the same sandstone appears in section 25 of Waterloo township; while in the other direction, it crops out in the washes and dry runs above Waterville, in the valley of Paint creek. The fact is, it is found at hundreds of local exposures,—wherever, indeed, the undulating surface of the region intersects its horizon,—in a broad belt several miles in width, extending from the northwest corner of Allamakee county to the mouth of the Yellow river.

American geology is indebted to Irving and Van Hise for practically all that has been written on the secondary enlargement of quartz grains in sandstones. It is not intended here to add anything to the descriptions and explanations of the phenomena of enlargements given by these authors in the Fifth Annual Report of the U. S. Geological Survey, in Bulletin No. 8 of the same survey, and in papers published in the *American Journal of Science.* The only purpose of this paper is to call attention to a geological horizon not enumerated in their list, and to a number of localities where one may collect specimens of sandstone exhibiting in remarkable perfection the interesting peculiarity of having facetted grains resulting from the deposit of an envelope of silica in optical continuity with the waterworn nucleus.

GEOLOGICAL NOTES ON THE SIERRA NEVADA.

By H. W. TURNER, Washington, D. C.

(Published by permission of the Director of the U. S. Geological Survey.)*

The Sierra Nevada is composed of a series of metamorphic sedimentary rocks, with which are associated large amounts of igneous rocks, granite, diabase, etc. On this older series of pre-Cretaceous age there rests with a marked unconformity a little altered series of sediments, tuffs and lava-flows of late Cretaceous and Tertiary age. The rocks are here treated of under two headings; first, the sedimentary formations, and second, the igneous rocks.

PART I.

THE SEDIMENTARY FORMATIONS.

The following formations have been recognized in the Sierra Nevada by the U. S. Geological Survey. The much metamorphosed auriferous slate series has, however, not been satisfactorily subdivided. Future discoveries will further unravel this complex.

Only those formations that are known to occur to the south of the fortieth parallel, comprising nearly the whole range, are included here. For information concerning the north end of the range the reader is referred to the publications of Mr. J. S. Diller, Prof. A. Hyatt, and Prof. Whitney. The formations are as follows:

Crystalline schists	Age ?
Grizzly formation	Silurian.
Calaveras formation	Lower ? Carboniferous.
Little Grizzly beds	Upper ? Carboniferous.
Mineral King beds	Triassic.
Cedar formation	Triassic.
Sailor Canyon beds	Jura-Trias.
Milton series	Jura-Trias ?
Mariposa slates	Jurassic.
Chico formation	Upper Cretaceous
Tejon formation	Eocene.
Ocoya Creek beds	Miocene.
Ione formation	Miocene.
Auriferous river gravels	Miocene and Pliocene.
Shore gravels	Pliocene.
Shore and river gravels, lake beds and moraines	Early Pleistocene.
Alluvium	Late Pleistocene.

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*These notes are in part an abstract of a paper that is scheduled to appear in the fourteenth annual report of the United States Geological Survey.

CRYSTALLINE SCHISTS.

Apart from the contact-metamorphic schists and mica schists, known to be in part of Jura-Trias and Carboniferous age, there are some areas of gneissoid schists, which may be much older. One of these is exposed in the canyon of the north fork of the Mokelumne river, to the east of the quartzite bluff known as Devil's Nose, on the Big Tree atlas sheet. These schists consist largely of brown mica and feldspar, but carry also at some points abundant quartz, monoclinic and rhombic pyroxene, and brown and green hornblende, with accessory minerals. The series is cut by numerous granite dikes. Only a superficial examination has thus far been made of these rocks.

GRIZZLY FORMATION.

This name has been given by Mr. Diller[*] to the Grizzly quartzite and Taylorville slates in which are limestone lenses, from which the following fossils were collected:

Crinoid stems.
Zaphrentis.
Heliolites.
Orthis.
Stromatopora.
Syringopora.
Halysites catenulatus.
Ormoceras.

A continuation of the slates of this formation appears in the northeast portion of the Downieville sheet, but no Silurian rocks are known to enter into the composition of the main mass of the range.

CALAVERAS FORMATION.

A large portion of the sedimentary rocks of the auriferous slate series consist of argillite, quartzite and mica-schist, with lenses of limestone. Few determinable fossils have been found in these rocks and these chiefly in the limestone lenses. Rounded crinoid stems, suggesting the Paleozoic era, have been collected at many points by the U. S. Geol. Survey, and in addition the following more characteristic fossils:

Pleurotomaria.
Polyphemopsis.
Loxonema.
Spirifera.
Phillipsastrea.
Clisiophyllum gabbi.
Lithostrotion whitneyi.
Fusulina cylindrica.

The limestone at Pence's ranch[†] containing *Productus*

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[*] Text, Lassen peak sheet, and Bull. Geol. Soc. Am., vol. 3, p. 376.

[†] Geology of California, vol. i, p. 210.

semireticulatus and *Spirifera lineata*, and the Bass ranch locality in Shasta county, are in the Calaveras formation, as is also presumably the locality on the McCloud river near Baird P. O.

Dr. Gabb* gives the following fossils from the Bass ranch locality:

Fusulina robusta.
Fusulina gracilis.
Fusulina cylindrica.
Lithostrotion.
Clisiophyllum gabbi.
Productus semireticulatus.
Rhynchonella.
Spirifera lineata.
Spiriferina.
Retzia compressa.
Euomphalus whitneyi.
Orthis.

Mr. Walcott is of the opinion that the above assemblage of fossils indicates the Lower Carboniferous.

The term "Calaveras formation" was first used in print in the AMERICAN GEOLOGIST (vol XI, p. 309), and the definition was modified in the next issue (June, 1893). *Fusulina* has been found by the writer near Hite's Cove, on the south fork of the Merced river, in limestone that is a part of the great limestone belt of the Gold Belt. The large limestone masses of this belt at Sonora, Murphy's, Cave City, Volcano, and on McCormick's ranch nine miles east of Plymouth, are all nearly in a line and pretty surely of the same age. Rounded crinoid stems have been found at several of the above localities, but the fossil which indicates with certainty the age of the belt to be Carboniferous is the *Fusulina* near Hite's Cove.

Fusulina, crinoid stems and some other fossils were obtained by Mr. C. D. Voy and by the writer from the limestone belt of the Bear mountains, mostly in the northward continuation of this belt in Calaveras and Amador counties. Mr. T. W. Stanton and myself collected *Fusulina* and other fossils from limestone south of Onion valley creek in Plumas county, about three and a half miles up-stream from the mouth of the creek, and Mr. Stanton collected some from limestone on Spanish creek one mile east of Spanish Ranch P. O. This last discovery is interesting, as the limestone forms one of the outcrops described by Mr. Jas. E. Mills† as of Mesozoic age. The Calaveras formation has also been recognized by Mr. Lindgren at a number of points in the American river drainage. There is little doubt that it comprises perhaps the larger part of the sediments of the auriferous slate series.

LITTLE GRIZZLY CREEK BEDS.

At the southwest base of Mt. Ingalls, by the road to the Cascade gravel mine and to the east of Little Grizzly creek, there occurs a highly metamorphic tuff, in a fine-grained portion of which are recognizable fossils.

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* Paleontology of California, vol. i, pp. 1–16.

†Bull. Geol. Soc. Am., vol. 3, p. 428.

The following fossils were collected here by Dr. Cooper Curtice, Mr. W. T. Turner and Mr. T. W. Stanton. Through the kindness of Mr. C. D. Walcott these were examined by Mr. Charles Schuchert, of the U. S. Geological Survey, who reports upon them as follows:

"The collection from Little Grizzly creek, Plumas county, California, shows the fossils to be of *Upper Carboniferous* age. The common forms are of the following species:

Archeocidaris, plates and spines like those of *A. ornatus* Newberry, and *A. trudifer* White.

Chonetes n.sp. A very common, large, subquadrate and very convex species.

Productus longispinus Sowerby.

Productus semireticulatus ?

Orthis (*Schizophoria*) *pecosi* Marcou.

Rhynchonella (*Uncinulus*) n.sp. ?

Spirifer n.sp. Related to *S. camerata* Morton and *S. musakheylensis* Davidson.

Spirifer (*Reticularia*) *lineatus* Martin.

Spiriferina cristata Schlotheim. The large variety.

This fauna is closely related to that of the Robinson* beds. The species of the latter locality are known to me only by the list published by Mr. Diller."

These beds are stratigraphically nearly in a line with the Robinson beds, which are considered by Mr. Walcott to be of Upper Carboniferous age, and which are also in part composed of volcanic materials.

Both of these localities lie at the east base of the Sierra Nevada, and the formation represented may not enter into the composition of the main mass of the range.

MINERAL KING BEDS.

The attention of the writer was first called to this locality by specimens in the collection of the California State Mining Bureau. Later Mr. Becker and the writer paid a visit to the locality and a lot of the fossils were collected by the writer and sent to Washington. They were all much distorted, and Mr. Walcott and Dr. White on examining them could only say that they were Triassic. Mr. Stanton later examined them and identified a plicate form of an *Ostrea*, and somewhat doubtfully *Pecten*, *Lmia*, *Mytilus* and *Halobia*.

CEDAR FORMATION.

This was established by Mr. Diller† and includes the horizon of the Hosselkus limestone. It is characterized by pentagonal crinoid stems, *Monotis*, and so forth. Mr. James E. Mills* has called attention to a bed of conglomerate in this formation on Rush creek in Plumas county, containing pebbles of granitoid and other intrusive igneous rocks, plainly indicating the existence of a land area and presumably a mountain range in the northern Sierra Nevada before the deposition of the Cedar formation. The slates of the Cedar formation on Rush creek are continued southward across the east branch of the north fork of the Feather river and form part of the high ridge to the north of Meadow valley. Except that *Monotis* has been found at Sailor canyon, there is no evidence of the existence of this horizon in the central or southern Sierra Nevada.

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*Bull. Geol. Soc. Am., vol. 3, p. 375.

† Text of the Lassen peak sheet.

SAILOR CANYON BEDS.

At Sailor canyon, which drains into the American river about six miles southeast of Cisco, are a series of beds from which Mr. Lindgren and Dr. Cooper Curtice have collected fossils, concerning which Prof. Hyatt states:†

"The discovery of *Monotis* beds above the Carboniferous in American cañon, south of Cisco, California, show the probable existence of the Trias there, but just above these, in Sailor's cañon, occur beds of *Daonella* which were more doubtful. The Daonellæ, although hitherto considered exclusively Triassic, occur in part near the upper limits of their distribution in curious association with Ammonitinæ of very doubtful aspect. These Ammonitinæ are not, as a whole, like any fauna heretofore described as Triassic. They have a distinctly Liassic facies, and with them Dr. Curtice found two specimens of Aptychi of the rugose type, which in Europe have not yet made their appearance below the Upper Lias."

MILTON SERIES.

The first locality to the south of Genessee valley where there is evidence of the Jura-Trias is on the southeast slope of the Sierra buttes. Some years ago the writer saw in the collection of Mr. C. W. Hendel, of Laporte, Plumas county, a very distinct impression of an ammonite on a piece of black slate, which Mr. Hendel informs me was obtained by a miner from the spot where the mill of the Phœnix gold quartz mine now stands. There is at this point a narrow lens of black siliceous slate included in quartz-porphyry, which is the country rock of the mine, and the ammonite presumably came from this slate lens. Mr. Stanton examined this locality for fossils, but found none.

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* Bull. Geol. Soc. Am., vol. 3, p. 429.

† Abstract in Am. Jour. Sci., vol. 47, p. 142. The abstract is not quoted word for word.

There are a number of lenses of precisely similar black siliceous slate in the quartz-porphyry, etc., that forms the crest of the ridge extending north from the Sierra buttes, and it is therefore probable that all of these rocks, both the lenses and the enclosing igneous rocks, are Jura-Trias in age.

Apparently overlying the igneous rocks that contain the siliceous slate lenses are a series of comparatively little altered sediments containing a large amount of fragmental diabasic material with some quartzite, fine-grained, reddish, clastic rocks, a variegated breccia and a few limestone lenses. The series is best exposed along and east of the north fork of the Yuba river, in the southeast corner of the Downieville sheet, in the neighborhood of the old stage station known as Milton, and the rocks are therefore provisionally called the Milton series.

The breccia contains abundant small fragments of phthanite, and other rocks of various colors. Pebbles of this breccia have been noted by the writer at a number of points in the Neocene auriferous gravels. Limestone was seen at two points only, both of the bodies being at the contact with the granite area to the east, and having yellow and reddish garnets, presumably as a result of granitic contact metamorphism. The hardened sandstone or quartzite of the series contains a good deal of authigenetic brownish-green mica in minute foils, which may likewise be ascribed to metamorphism. There is, therefore, little doubt that the series is earlier in age than the granite mass to the east. This body of tuffs and sediments shows very little evidence, both macroscopically and microscopically, of having been greatly compressed. Not only, as a rule, has every little slaty structure been developed, but under the microscope the augite and feldspar prisms and the quartz grains show little evidence of crushing. The series, as a whole, has a remarkably uniform dip of from 45° to 50° to the east. At the granite contact the dip is in places much steeper. It is probable that these rocks are Jura-Trias in age, although fossils have not been found in any portion of them. The series seems to rest unconformably on the presumably Paleozoic sediments that form the mass of the range on the Downieville sheet west of Milton. These Paleozoic (?) rocks consist of black slates, quartzite and limestone, with intrusive quartz-porphyry, gabbro, etc. They stand approximately vertical and are much compressed. The difference in the lithological characters of the two sets of rocks, the fact of one showing much evidence of dynamo-metamorphism and the other comparatively little, and the marked difference in dip of the two bodies, taken as a whole, strongly suggest an unconformity.

Mariposa Formation.

The Mariposa slates constitute the most definite of the formations that have been recognized in the auriferous slate series. Where studied by the writer to the south of the American river this formation consists almost wholly of black, clay slates, with layers of diabase-tuff and a little conglomerate, made of siliceous pebbles from the rocks of the Calaveras formation. The Mariposa slates were considered of Jurassic age by Gabb and Meek, who determined the following fossils:

Ammonites[*] colfaxi.
Aucella erringtoni.
Aucella erringtoni, var. linguiformis.
Pholadomya ? orbiculata.
Belemnites pacificus.

The U. S. Geol. Survey has collected fossils at a number of localities in the Mariposa slates. The most prolific of these is the Texas ranch in Calaveras county. The following fossils were obtained here by Mr. C. D. Voy and Dr. Cooper Curtice, and determined by Dr. White and Prof. Hyatt.

Aucella erringtoni.
Perisphinctes.
Belemnites pacificus.
Amaltheus.
Cardioceras.

There is some difference of opinion as to the age of the Mariposa slates. Prof. Hyatt[†] is of the opinion that the Aucellæ and the Ammonitinæ of the genera *Cardioceras* and *Perisphinctes*, from Mariposa, Calaveras, and Tuolumne counties prove the Upper Jurassic age of the slates. The species of *Cardioceras* and *Perisphinctes* have the common characteristics of similar forms found in the Upper Jura of Russia, and these occur in association with similar forms of Aucellæ. The species of Aucellæ differ, as a whole, from those of the Knoxville slates in being almost invariably ornamented with radiating striæ. Only one species, *Aucella erringtoni*, var. *arcuata* approximates in outline to the well-known narrow form of *Aucella piochi*. The conclusion is reached that the fauna of the Mariposa beds is Upper Jurassic and older[‡] than the Knoxville formation, which is usually regarded as Neocomian.

Dr. White considers the Aucellæ in the Mariposa beds and those in the Knoxville beds of the Coast ranges to belong to the same species, although a very variable one. He therefore concludes that both series of beds are of the same age (Neocomian), at the same time recognizing the close resemblance of some of the ammonites to Jurassic forms of Europe. Outside of the paleontologic evidence, there are certain facts in the physical geology of the Knoxville and Mariposa beds which lead the writer to believe the latter to be the older.

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[*] Prof. Hyatt states that this ammonite belongs to the genus *Perisphinctes*. The specimen is now in Cambridge.

[†] Am. Jour. Sci., vol. 47, p. 143.

[‡] The abstract in the Am. Jour. Sci., says younger, but is a mistake.

The Knoxville beds consist of sandstones and shales, which are never greatly altered; at least this is true of all those portions of the beds of which the age is certainly known by the presence of fossils. The strata have been nowhere greatly compressed, so that no slaty structure has been developed. The Aucellæ and other fossils found in the Knoxville beds have seldom been compressed or otherwise distorted. They not only present their proper form, but the original shells of the fossils are generally present. The strata have nowhere, so far as known, been intruded by granite* or diabase, although serpentine dikes occur in them.

The Mariposa beds on the other hand have been greatly compressed, in places forming a good roofing slate; the fossils in them are also compressed, and the original shells of the fossils have in all cases disappeared. The strata are, moreover, intruded by diabase and granite. The fact of the Mariposa beds, as well as the other auriferous slates, having been cut off and metamorphosed by granite to the south of Mariposa was first noticed in print in this journal, vol. 7, 1891, p. 211, by Mr. Fairbanks. Although not stated by the author, the Mariposa beds form a part of the twenty miles of slates "that are greatly broken and metamorphosed." In December, 1893, the writer examined the region about Mariposa and corroborated Fairbanks' general results, although he is mistaken in stating that the "granite extends down from the high Sierras, cuts across all the other formations and terminates five miles west of the town of Mariposa." The granite of the high Sierras is separated from the granite area south of Mariposa by a tongue of mica-schist and greenstone schists, which extends southeast from Sevastopol across the Chowchilla to the mining camp of Grub Gulch, and doubtless still further south, possibly to the Kaweah river sedimentary series, as schists are known to occur at several intermediate points.

There is no possible doubt, however, of the Mariposa slates being metamorphosed by the granite area that extends from Mormon Bar, south of Mariposa, to the San Joaquin river. This large granite mass may be of the same age as the hornblendic granite to the east of the narrow schist belt just described; at most points, however, it contains little or no hornblende, but black mica is abundant. The Mariposa slates west of Mariposa, where they terminate abutting against the granite, have been pushed out of their normal northwesterly strike near the granite, in places striking east and west. They have, moreover, been converted into mica-schists, which at some points, as in Yagui gulch, carry small andalusite crystals. According to Fairbanks, the clay slates, one-fourth mile from the granite, contain needles of fibrolite.*

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*The following note is added as bearing indirectly on the subject, for the metamorphic Coast range series is either as held by Whitney and others of the same age as the Knoxville beds, or older. The note is as follows: Mr. Fairbanks stated to me that he has discovered a basal conglomerate in the Coast range metamorphic rocks in Monterey county, containing granite pebbles, so that he no longer regards the granite of the Gavilan range as intrusive in the Coast range metamorphic series, as stated in the AMERICAN GEOLOGIST, vol. XI, p. 71.

In the lower foothills of Madera and Mariposa counties is a belt of mica-schist, portions of which carry large andalusite crystals in great abundance. Attention was called to this schist belt many years ago by Prof. Blake. The Ne Plus Ultra and Buchanan copper mines are in these schists. This belt may also be a metamorphosed area of Mariposa slates. At Merced Falls, at the very west edge of the foothills on the Merced river, is a belt of clay slates, which is probably the southward continuation of the western belt of the Mariposa formation, which extends from Folsom through Salt Spring valley southward. The general strike of this belt of clay slates would carry it into the Chowchilla mica-andalusite-schist area.

The Mariposa slates form an integral part of the auriferous slate series. The dip of the slates is usually from 70° to vertical. At Folsom a little west of the bridge over the American river, are nearly horizontal unaltered sandstones containing Chico fossils; while not far east of the bridge are contact mica-schists of the Mariposa formation dipping at a high angle. No more conspicuous unconformity exists in the Sierra Nevada than that between these unaltered Chico strata and the neighboring metamorphic schists of the Mariposa formation. The possibility suggested by Mr. Diller† of the upheaval of the Mariposa beds having occurred after the Chico or Miocene beds were deposited, cannot be entertained.

CHICO FORMATION.

The sediments of the Chico formation where seen in the foothills of the Sierra Nevada consist chiefly of sandstone and conglomerate. In the areas examined by the writer the dark shales that form part of the series in the Coast ranges do not appear. These sandstones lie with a marked unconformity on the rocks of the auriferous slate series. The beds frequently have a gentle dip toward the valley. The most southern locality in the gold belt where the Chico formation is known with certainty is at Folsom on the American river, where the beds have an altitude of two hundred feet above sea level. Prof. Whitney first called attention to this locality. From here north Chico beds have been found at various points, the altitude increasing with the latitude. At Pentz P. O. in Butte county the beds are about 400 feet in elevation; on Chico creek 500 feet or more; underlying Shasta valley 2,500 feet, and nine miles northeast of Yreka 4,000 feet, the last two localities being given on the authority of Mr. Diller. There is thus evidence of an increasing elevation, going north, of the mountains of northern California since the deposition of the Chico beds.

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*Tenth Ann. Rep. State Mineralogist of Cala., p. 30.

†Bull. Geol. Soc. Am., vol. 4, p. 122.

The following is a report by Mr. T. W. Stanton on the Chico fossils collected chiefly by T. W. Stanton and H. W. Turner from Butte county:

"Cretaceous Fossils from Butte County, California.

Pence's Ranch.

Anomia lineata Gabb.
Mytilus sp. undet.
Perna excavata White.
Pectunculus veatchi (Gabb).
Arca sp. undet.
Nucula truncata Gabb.
Trigonia leana Gabb.
Crassatella tuscana (Gabb).
Tellina ooides Gabb.
Lutraria truncata Gabb.
Mactra (Cymbophora) ashburneri Gabb.
Mactra sp. undet.
Corbula traski Gabb.
Mesalia obsuta White. Type of species.
Ceratia nexilia White. Type of species.
Gyrodes conradiana Gabb?
Scalaria mathewsoni Gabb?
Haydenia impressa Gabb.
Cominella lecontei White. Type of species.
Fulgur hilgardi White. Type of species.
Potamides tenuis Gabb.
Scobinella dilleri White.
Perissolax brevirostris Gabb.
Eripachya ponderosa Gabb.
Baculites chicoensis Trask.

Chico creek, 10 miles N. E. of the town of Chico.

Pecten sp. undet.
Inoceramus whitneyi Gabb.
Cucullæa truncata Gabb.
Crassatella tuscana Gabb.
Cardium (Protocardia) placerensis Gabb.
Clisocolus dubius Gabb.
Chione varians Gabb.
Mactra (Cymbophora) ashburneri Gabb.
Mactra sp. undet.
Gyrodes expansa Gabb.
Ceratia nexilia White.
Perissolax brevirostris Gabb.
Sycodes cypræoides Gabb.
Rostellites gabbi White.
Cinulia obliqua Gabb.
Baculites chicoensis Trask.
Ammonites newberryanus Meek.
Ammonites sp. undet.

Butte creek, near Centerville.

Inoceramus whitneyi Gabb.
Modiola sp. undet.
Cucullæa truncata Gabb.
Pectunculus veatchi (Gabb).
Nucula truncata Gabb.
Trigonia evansana Meek.
Trigonia leana Gabb.
Trigonia navis Gabb.
Crassatella tuscana (Gabb).
Cardium (Protocardia) placerensis Gabb.
Clisocolus cordatus Whiteaves.
Chione varians Gabb.
Cytherea nitida (Gabb).

Cytherea longa (Gabb).
Tellina ashburneri Gabb.
Tellina ooides Gabb.
Tellina n. sp.
Lutraria truncata Gabb.
Mactra (Cymbophora) ashburneri Gabb.
Mactra n. sp.
Pholadomya breweri Gabb.
Martesia clausa Gabb.
Dentalium cooperi Gabb.
Dentalium stramineum Gabb.
Gyrodes expansa Gabb.
Anchura falciformis Gabb.
Turritella veatchi Gabb.
Mesalia obsuta White.
Potamides tenuis Gabb.
Ceratia nexilia White.
Faunus marcidulus White. Type of species.
Rostellites gabbi (White). Figured specimen.
Eripachya ponderosa Gabb.
Perissolax brevirostris Gabb.
Fusus averilli Gabb.
Actaeon sp. undet.
Cylichna costata Gabb?
Baculites chicoensis Trask.
Ammonites chicoensis Trask.
Ammonites n. sp.

"The fossils from these localities, like those from all the other Cretaceous localities on the east side of the Sacramento valley, belong to the typical Chico fauna. The strata from which they came are probably not the oldest Chico beds, though several of the most prominent species range down to the base of the Chico and into the Horsetown beds in the thick sections on the west side of the Sacramento valley. On the other hand, these typical Chico strata from which the formation was first named seem not to represent the latest Cretaceous time; for their fossils do not show any intimate relationship with the fauna of the Tejon (Eocene), which has been supposed to follow the Chico without interruption. This view is strengthened by the fact that the fossils, especially the Ammonites, from the base of the Chico where it blends with the Horsetown indicate an age not later than the Cenomanian for that portion of the formation."

Tejon Formation (Eocene).

So far as known, strata containing shells of the Tejon formation have been found in the Gold Belt region only at the Marysville buttes, where they were collected by Mr. Lindgren. Tejon fossils have not been reported from the foothills of the Sierra Nevada between the Marysville buttes and the original locality in the Tehachapi range, the Téjon ranch.

At the west base of the north end of Oroville table mountain about one mile south of Pentz P. O., the writer collected casts of a strongly concentrically ribbed shell, associated with stems of fossil plants. The shells were determined by Dr. White and Mr. Stanton as belonging to *Corbicula*, a genus found only in fresh and brackish waters. The *Corbicula* bed overlies sandstones containing abundant Chico fossils, and underlies the white shales and clay of the Ione formation that is capped by the basalt of the table mountain. It is possible that the *Corbicula* bed represents the Eocene period and perhaps the Puget group of Washington.

OCOYA CREEK BEDS.

Prof. W. P. Blake* reported extensive deposits of Miocene age in Tulare county on Ocoya or Posé creek and further south.

The fossils collected by Blake were casts, and from these Mr. Conrad described a number of species. As there is a probability that all of these fossils cannot hereafter be recognized, only the following are given, these having been identified by Gabb from later collections:

Agasoma gravida GABB; undet. CONRAD.
Natica recluziana GABB; ocoyana CONRAD.
Pecten catilliformis CONRAD.

A considerable number of shark teeth were found and studied by Prof. Louis Agassiz. According to Prof. Whitney, the upper portion of the beds are of a later and fresh water origin and contain fragments of bone and wood. There is a possibility of correlating the Ione formation with these beds.

IONE FORMATION.

This term was first used by Mr. W. Lindgren, in the descriptive text of the Sacramento sheet, for the beds of clay and sand, with layers of lignite, that occur along the foothills of the Sierra Nevada and seem to have been deposited at the same time as the earlier auriferous river gravels, which are usually composed chiefly of white quartz pebbles. The series is best developed in Amador and Calaveras counties, where the writer has been able to separate it into three portions, as follows, in descending order:

Ione formation.
1. Ione clay rock or tuff—100 feet or more in thickness.
2. Ione sandstone—100 feet or more in thickness.
3. White clay and sand beds containing coal seams—860 feet or more.

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*Pacific Railroad Reports, vol. 5, pp. 164-173.

The Ione clay rock or tuff is light in color, but usually more or less discolored. The fracture is irregular as a rule, and it frequently contains minute tubular passages. Under the microscope it is seen to be composed of fine particles of feldspar and minute discolored fragments, with some quartz grains. The Ione clay rock is best developed west of Valley Springs. Analyses show silica contents varying from 52% to 72%, and alkali contents varying from 1.62% to 4.87%.

The Ione sandstone plainly underlies the clay rock, as may be finely seen on the south bank of the Mokelumne river at the Camanche bridge. The sandstone is usually white in color, but sometimes red, and occasionally passes over into a conglomerate with abundant quartz pebbles. It is quarried and used for building purposes, one of the red varieties bringing a good price in San Francisco. At the quarry from which this red rock comes, three miles southeast of Buena Vista in Amador county, the Pliocene shore gravels rest unconformably on the waterworn surface of the sandstone, here laid bare by the quarrying operations.

Very characteristic of the Ione sandstone is a hydrous silicate of aluminum, occurring largely as white pearly scales. The mineral under the microscope shows low polarization colors and seems to extinguish parallel to the basal cleavage. The following analysis of the material was made by Dr. W. F. Hillebrand, who separated the foliated mineral from the quartz and other constituents by means of the heavy solution:

Silica..............	55.88	Lime................	trace
Titanic acid........	.50	Potash.............	.42
Alumina...........	30.24	Soda...............	.34
Ferric oxide........	.42	Water below 100°C.	.63
Ferrous oxide......	.16	Water above 100°C.	11.72
			100.31

The material analyzed showed under the microscope only a few particles of quartz in the field of view. The foliated mineral comprised all the remainder of the material. Perhaps 1% or 2% of silica might be deducted as coming from these quartz grains. Prof. S. L. Penfield, to whom the material and thin sections were sent for examination, says that "as the aluminum silicate is not clear and transparent it is impossible to be sure that it does not contain microscopic quartz or chalcedony silica deposited on it," and is inclined to think the mineral an impure kaolinite.

The white clay and sand beds are the lowest in the series and are best exposed about Ione, where the coal seams they contain are mined. At coal mine No. 3, borings to the depth of 860 feet from the surface are reported in these clay and sand beds.

Mr. W. Lindgren found a series of beds of sandstone and clay with layers of lignite at the Marysville buttes, from which he obtained marine fossil shells said by Dr. W. H. Dall to be of Miocene age. Mr. Lindgren considers these beds to belong to the Ione formation. The series as a whole was undoubtedly, however, deposited in fresh or brackish water. Search for fossils has been made at numerous points, but excepting leaves in coal mine No. 3, the writer has thus far found nothing. These leaves were not well preserved. The most numerous were those of a coniferous tree, probably belonging to the cypress family, possibly *Sequoia*.

The division of the Ione formation into three portions, which the writer found to be good everywhere in Amador and Calaveras counties, does not appear to obtain in Butte county, where the deposits underlying Oroville table mountain are composed largely of fine white shales and clay, the overlying sandstone and peculiar clay rock not being represented.

NEOCENE AURIFEROUS RIVER GRAVELS.*

Under this term are included on the maps of the Gold Belt, the river gravels which occur chiefly on the ridge tops where they were deposited in what were then valleys before the present deep canyons in the range were cut. These gravels are of different ages, but may be divided into two main groups: 1st, The older gravels, composed chiefly of white quartz pebbles, and frequently capped by rhyolitic flows. These may be characterized, in a broad way, as the gravels formed before the volcanic period. 2d, A later series, containing volcanic pebbles chiefly of andesite, and later in age than the rhyolitic flows. These may be called the gravels of the volcanic period. Such gravels are often capped by andesite-tuff.

At a large number of localities fossil leaves have been found in fine layers in the gravel, and silicified wood of both deciduous and coniferous trees, as well as of palms. The leaves indicate that the older gravels are of Miocene age. The later gravels belong to the Pliocene period.

PLIOCENE SHORE GRAVELS.

Overlying the Ione formation and forming level tops to the ridges in the foothills of Amador and Calaveras counties are conglomerate and gravel beds, best seen to the west and southwest of Valley Springs. The pebbles in this material are from a variety of rocks, quartzite, mica-schist, quartz-porphyrite, granitoid rocks, andesite, and rhyolite being represented. Rhyolite pebbles are in places so abundant as to be characteristic of the material.

The Pliocene shore gravels are of the same age as the later auriferous river gravels. They appear, however, to have been deposited in the waters of the gulf that formerly occupied the basin of the great valley. Where studied by the writer in Amador and Calaveras counties, these gravels merge into the Pliocene river gravels. This is particularly noticeable to the east of Valley Springs. They may, therefore, be said to represent, in part, a delta formation, but the main mass of them, occurring as a capping to the ridges, is more properly designated as shore gravel.

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*Neocene includes the Miocene and the Pliocene.

The unconformity of these gravels on the Ione formation is plainly seen at the sandstone quarry, three miles southeast of Buena Vista, where they rest on the undulating and smooth water-worn surface of the Ione sandstone. Water-worn boulders of the sandstone occur in the gravel. In a cut of the San Joaquin and Sierra Nevada railroad, one mile southwest of Valley Springs, the gravels are well exposed and attain a thickness of two hundred feet. At the bottom of the cut may be seen irregular blocks of the gray clay-rock or tuff of the Ione formation included in the gravel beds. The unconformity of the Pliocene shore gravels on the rhyolitic series may be seen at Valley Springs peak and at Buena Vista peak. At both places the gravels contain abundant pebbles of the rhyolite that forms these two peaks. These heavy bodies of coarse gravel suggest the Pliocene to have been a period of rapid erosion. These gravels attain at Valley Springs peak a maximum elevation of 1,000 feet. The great bulk of them are from 500 to 700 feet above sea level.

EARLY PLEISTOCENE SHORE AND RIVER GRAVELS AND MORAINES.

The early Pleistocene shore gravels consist almost entirely of quartzite and other highly siliceous pebbles. They appear to have been formed largely from Neocene (Miocene and Pliocene) gravels, from which the softer pebbles of igneous rocks were eliminated by long continued washing by the gulf waters. There are extensive areas of these gravels on the east side of the San Joaquin and Sacramento valleys. On the Jackson sheet they occur as low, broad plateaus, and in the depressions between the Neocene and older hills up to an elevation of 450 feet. They attain a maximum elevation of 500 feet at the Irish Hill gravel mine, four miles northwest of Ione, in Amador county. The soil of the Pleistocene shore gravels is red in color. Since these gravels rest on the Ione formation or on andesitic tuff, it is plain that the quartzite pebbles could not have been derived directly from quartzite croppings, which, moreover, do not occur along the west edge of the foot-hills, but only at a greater elevation than was attained by the Pleistocene gulf waters. The Pleistocene shore gravels have been proved at many points auriferous. They have been extensively washed on the plateau southwest of Camanche, and also along the Mokelumne near Camanche, at the North Hill mine near Jenny Lind, at Irish Hill, and other points.

The river deposits of early Pleistocene age consist of gravels along the present rivers lying usually less than one hundred feet above the present river level. There is much more variety in the pebbles of these gravels they having been formed chiefly from the hard pre-Cretaceous rocks, in which the river canyons are cut. The early Pleistocene river gravels have, as a rule, proved highly auriferous. Some of the Pleistocene streams have changed their courses for short distances, having cut through some barrier. This is the case with the Mokelumne river, one mile west of Lancha Plana, on the Jackson sheet, and also with Slate creek, on the Bidwell Bar sheet, just before it joins the Yuba river. The gravels in the deserted beds of both of these streams have been mined for gold.

Some of the valleys of the range were occupied in early Pleistocene time by lakes. This is the case with Mohawk valley* in Plumas county, and with Meadow valley, at the head of Spanish creek. The lake in Mohawk valley was caused by the waters of the Feather river being dammed back by an eruption of andesite-breccia, while the basin of Meadow valley appears to have been formed by orographic causes. The gravel-benches about Meadow valley that were formed by this early Pleistocene lake, attain an altitude of more than 4,000 feet, the lowest part of the valley having an altitude of 3,700 feet. Sierra valley was doubtless formerly occupied by a shallow sheet of water.

Moraines are very abundant and finely preserved in all that portion of the range where the higher points attained an altitude of 8,000 feet or more. The glaciers were local and with only minor exceptions they followed the course of the present drainage system. They evidently attained their maximum development after the formation of the present canyons. As was stated by Prof. I. C. Russell,† there are rudimentary glaciers still in existence in the high Sierra region east of Yosemite valley. One of the most easily seen of these was visited by the writer. This is on the north side of Mt. Dana. There is here a very pretty crescent-shaped terminal moraine, and the water of the little lakes below the glacier is yellowish from the silt, presumably due to the erosive action of the glaciers.

Prof. Joseph Le Conte‡ has studied the glaciers at Mono lake and lake Tahoe.

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*Bull. Phil. Soc. of Washington, vol. 11, pp. 385-410.

†Eighth Annual Report, U. S. Geol. Survey. Part I.

‡Am. Jour. Sci., 3d Ser., vol. 10, pp. 126-139.

ALLUVIUM.

There are gravels and fine sediments in all the valleys and along the rivers, that have been formed in the Recent period.

THE UPHEAVALS RECORDED IN THE ROCKS OF THE SIERRA NEVADA.

Pre-Carboniferous land area. In the portions of the range studied by the writer, comprising a strip thirty miles wide, extending across the mountains just south of the fortieth parallel, and a large part of the range to the south of Placerville in Eldorado county, the first record of a land area is that furnished by a bed of conglomerate in the foot-hills of Calaveras and Amador counties. This conglomerate is interstratified with slates and limestone, the latter containing *Fusulina cylindrica* and rounded crinoid stems, indicating the Carboniferous period. At one point in Calaveras county this conglomerate is within twenty feet of the limestone croppings, all the rocks having the same strike and dip. No fossils were found in the conglomerate itself, and therefore the possibility remains of its being of later age and folded in with the Carboniferous sediments.

This conglomerate contains pebbles of diabase, hornblende-porphyrite and quartzite, the igneous pebbles being much the most abundant. The conglomerate is well exposed in a field three miles northwest of Golden Gate hill (Nos. 22 and 56-59, Calaveras county collection), and west and northwest of Sugar Loaf (Nos. 30 and 31, Amador county collection), the last conglomerate stratum being to the east of the Willow Springs serpentine belt.

It is possible that the quartzite of Mt. Aigare and other similar masses in the southwest portion of the Placerville atlas sheet represent remnants of this hypothetical pre-Carboniferous land area. These quartzite masses have a somewhat irregular strike and dip, and in this respect vary from the Carboniferous belt lying to the east of Mt. Aigare, the rocks of which dip at a high angle and strike nearly north and south with great regularity. These quartzite areas, are, however, represented on the Placerville geological sheet as of the Calaveras formation, there being no positive evidence to the contrary.

Another conglomerate bed that is, perhaps, of Carboniferous age is exposed by the road to Cherokee to the south of Monte de Oro on the Chico atlas sheet. This contains pebbles (No. 149 Butte county) of fine grained siliceous rocks and of porphyrite. The black slate associated with the conglomerate contains some imperfect plant remains, so that fossils may yet be found to determine the age. The beds are presumed to be Carboniferous in age from being apparently the continuation of the series northeast of Pentz P. O., in the limestone of which Carboniferous fossils have been found.

Pre-Triassic land. As was noted under "Cedar formation," there is on Rush creek in Plumas county a bed of conglomerate interbedded with slates and limestone, the latter containing Triassic fossils. The writer visited this locality in company with Mr. Diller, who has in charge the geological mapping of the district. Quite a collection of the pebbles was made, and by permission of Mr. Diller the writer has examined a few of these. Quartz-diorite, diabase, and what is probably a diallage-olivine rock are represented. These pebbles will be studied further later.

The pre-Mariposa upheaval. As was noted by Mr. Becker,* the Triassic rocks at Mineral King are enclosed in granite giving evidence of a post-Triassic upheaval. The pre-Mariposa disturbance, of which the evidence is herewith briefly presented, may be identical with that which resulted in the upheaval and metamorphism of the Mineral King beds, but it is likewise possible that the Mineral King disturbance should be correlated with the post-Mariposa upheaval.

The pre-Mariposa upheaval, or, to speak more explicitly, the evidence of the unconformity of the Mariposa formation on the Calaveras formation, is shown by the following facts: First, the lithologic differences of the two formations, the Mariposa beds consisting uniformly of black clay slates, which contain locally thin layers of diabase-tuff and some conglomerate, while the Calaveras formation is made up of a variety of rocks, clay slates, quartzite, phthanite, and lenses of limestone. Second, the occurrence of a conglomerate in the Mariposa slates that is largely made up of phthanite pebbles, precisely like the phthanite of the Calaveras formation. Some of this conglomerate may be seen at the south base of Bear mountain, to the east of the Texas ranch fossil locality. Third, in the occurrence of a narrow streak of the Mariposa slates cutting across the Calaveras formation, with a slight diversity in strike. This narrow belt of slate extends from the Texas ranch fossil locality, which lies to the southwest of Bear mountain, northwesterly across the Calaveras formation, crossing the road from Milton to Angel's, one mile southeast of Carman peak. The same phthanite conglomerate that occurs near the Texas ranch is found with the slate where it is crossed by the road mentioned above. Fourth, the paleontologic break, the Calaveras formation representing the Carboniferous and probably the Lower

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*Bull. Geol. Soc., vol. 2, p. 206.

Carboniferous, while the Mariposa slates are of late Jurassic, or according to Dr. White, of early Cretaceous age; and, as the Mariposa slates are directly in contact with the Carboniferous rocks, there is plainly a long time hiatus.

The narrow streak of the Mariposa slates referred to in the foregoing paragraph seems certainly to have been deposited in a trough between pre-existing ridges of the Calaveras formation and to have been folded up with the rocks of that formation at the time of the post-Mariposa upheaval. The slates of both the Calaveras formation and of this narrow belt of Mariposa slates dip at a high angle to the east, but as before noted there is a slight diversity in strike.

Evidence similar to the above may be obtained by noting the strike of the two main belts of the Mariposa formation, which were first described in this journal, vol. 11, p. 308. The western belt of slate maintains a general northwesterly strike from near Folsom on the American river to Merced falls on the Merced river; the eastern belt, on the other hand, maintains a northwesterly strike from its south end near Mariposa to near Plymouth in Amador county, where it is flexed, pursuing thence a north course to Placerville, again bending northwesterly to the north of that town. The result is that the two belts, which are nearly parallel as far north as the Cosumnes river, diverge at an angle of about 30° to the north of that river.

The geographical distribution of the genus *Aucella* also indicates that a land area existed in the region now occupied by the Sierra Nevada, at the time the Mariposa beds were being deposited, for the genus is not found in the Jurassic deposits of the higher part of the range at Sailor canyon, nor in the highly fossiliferous Jurassic beds of Mt. Jura, in Plumas county.

The Hinchman tuff, which is the highest horizon recognized by Diller and Hyatt, is considered to represent not the very top of the Jurassic, but the Corallian of Europe, while the Mariposa beds are regarded, I think, by Hyatt as representing the uppermost Jura, so that our present knowledge suggests that all of California and Nevada to the east of the area of the Mariposa beds has been above water since the close of the Hinchman tuff (Corallian) epoch.

This distribution of the genus appears to favor the hypothesis of Dr. White and Mr. Becker that the Mariposa and Knoxville beds are of the same age. If it be supposed that a continuous series of Aucella-bearing beds were deposited on the western border of this pre-Mariposa land area, and that these deposits extended over the area now occupied by the Sacramento- San Joaquin valley and into the present Coast ranges, and that the orographic movements that uplifted, folded and metamorphosed the Mariposa beds were not strongly felt to the west of the great valley, it could be held that the Mariposa and Knoxville beds are merely different portions of this continuous series, the slaty structure and metamorphism of the Mariposa beds being due to their being in the zone of the intense dynamic movements that formed the Sierra Nevada, while the Knoxville beds, being out of this zone, were less disturbed and little metamorphosed. The facts, too, that serpentine is intrusive in the Knoxville beds, and that some of the granite of the Sierra is later than some of the serpentine of that range, might be used as an argument that the absence of intrusive granite in the Knoxville beds merely shows that no granite intrusions have occurred in the Coast ranges as late as the post-Mariposa granite of the Sierra Nevada.

Against the hypothesis of Mr. Becker and Dr. White, just discussed, is the opinion of Prof. Hyatt that the fauna of the Mariposa beds is not identical specifically with that of the Knoxville series. The proof of there having been a continuous sedimentation in the northern Coast ranges of California from the Knoxville epoch to the Chico, inclusive, that has lately been brought forward by Messrs. Diller* and Stanton†, resulting in establishing the Shasta-Chico series, also does not favor this hypothesis, since, as before noted, the Chico is conspicuously unconformable on the Mariposa slates at Folsom.

The proof of the intrusion of serpentine into the Knoxville beds is, however, unquestionable, and if the large areas of serpentine in the central Coast ranges are also post-Knoxville in age, it seems almost certain that a disturbance of the Knoxville beds must have occurred at the time of the extrusion of the basic igneous rock from which the serpentine is derived.

Post-Mariposa upheaval. As was shown many years ago by Prof. Whitney, the Sierra Nevada was upheaved as a great mountain range after the Mariposa beds were deposited. Evidence has already been presented under "Mariposa formation," showing that granitic rocks were intruded into the slates of the Mariposa formation at the time of this upheaval. It is indeed possible that much of the granite of the range dates from this upheaval.

Post-Tertiary elevation. During Cretaceous and Tertiary time, the Jurassic Sierra Nevada had been reduced to an approximate peneplain. In the late Tertiary a large part of the western slope was covered with volcanic materials, extensive areas of which still remain, preserving underneath them the Tertiary peneplain, the drainage system of which is represented by the Neocene auriferous river gravels.

About the close of the Tertiary the range was elevated and the streams, with added force of gravity, cut new and deep cañons in the hard eroded base of the Jurassic range in a surprisingly short time. This elevation of the range was not accompanied by the folding of the strata, but the formation of a series of normal faults appears to date from this time.

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*Bull. Geol. Soc. Am., vol. 4, pp. 205-224.

†Ibid., pp. 245-256.

Since the post-Jurassic disturbance, there then appears to have been no great orographic movements in the Sierra Nevada, accompanied by crumpling and folding of the strata. The block of the earth's crust that has been practically rigid since that time is a large one, embracing about 20,000 square miles, and taking in practically the entire Sierra Nevada and all that portion of the great valley to the east of the San Joaquin and Sacramento rivers. It has been shown by Gilbert, Le Conte and others, as is well known, that the east edge of this great block is bounded by a zone of normal faults, which have produced an eastern escarpment which is most marked west of Mono and Owen's lakes; but, so far as known to the writer, attention has not been called to the west border of this block, which is perhaps also bounded by a zone of fractures along which normal faults may have formed. The proposition is here advanced as a working hypothesis that a great fracture, or, rather, series of fractures, exists at about the middle of the great valley, which line of fractures is approximately followed by the Sacramento and San Joaquin rivers. The southward continuation of this hypothetical line of fracturing may cut the Tehachapi range, for Prof. Whitney* writes: "As we skirt the base of the Sierra, however, in the région where this chain turns to the west towards Fort Téjon, we pass at once from undisturbed Tertiary to strata of the same age which are elevated at a high angle, and in so doing we leave the system of the Sierra, and pass over to that of the Coast ranges. This change takes place about midway between the Téjon pass and the Cañada de las Uvas; but no break in the mountain ranges indicates this transition."

While the Cretaceous and Tertiary beds to the west of the great block above outlined have been crushed and folded to an enormous extent, forming extensive ridges in the present Coast ranges, the block itself has been practically rigid, as is evidenced by the nearly horizontal beds of Cretaceous and Tertiary strata that occur along the foot hills, and by the Tertiary tuffs and river deposits, also nearly horizontal, that cap many of the ridges even near the crest of the range.

How much faulting, if any, has taken place along the series of fractures that are supposed to exist along the western edge of this orographic block, is not known, but the existence of faults along the east edge is beyond question, and these normal faults appear to have been formed at the close of the Tertiary, chiefly as a result of "gravitating settling" which followed the elevation of the ridges at that time.

Recent elevations of the range. It is well known that much of the coast of California has risen in recent times. This is shown by the finely preserved wave-cut terraces along the coast that now stand some hundreds of feet above sea level, and concerning which Prof. Lawson† has recently written a valuable paper. If the Pleistocene gulf or inland sea that oc-

*Geol. California, vol. I, p. 167.

†Bull. Dept. Geol., Univ. of California, vol. I, pp. 115-160.

cupied the great valley was at or near sea level, it is obvious that the region of the great valley has also risen, since it is now high and dry. The Inyo earthquake of 1872 may have been due to a slipping along the normal fault zone of the eastern escarpment, which was, perhaps, accompanied by an upward movement of the crest directly west.

[To be concluded in next number.]

A CLASSIFICATION OF ECONOMIC GEOLOGICAL DEPOSITS BASED ON ORIGIN AND ORIGINAL STRUCTURE.*

By W. O. Crosby, Boston, Mass.

Introduction.

The title of this paper might be otherwise expressed as the enumeration and brief description in natural order of the various modes of origin and occurrence of useful minerals and rocks. A strictly natural classification on economic lines is, of course, impossible; simply because nature has shown no special regard for our economic distinctions. The position of a rock in the natural classification is essentially the same, whether it contains one grain, one ounce, or one pound of gold to the ton. The economic classification must, in every instance, be a fragmentary scheme, lacking the completeness and perfect coördination or symmetry which we recognize or believe to be recognizable in nature; for it represents a body of knowledge having arbitrary or artificial and shifting boundaries. A mineral which is valueless to-day may find a useful application to-morrow, and thus, perhaps, introduce into the economic classification a new type of deposit; and in like manner the deposits of a particular type may be dropped from the economic scheme, if the substance which they afford be supplanted in its relations to human welfare by some other. The most nearly ideal plan would, it is believed, be a completely elaborated natural or scientific classification, with a special mark to designate those deposits of present economic interest. The practical man, who often cares little for the general relations to the whole of the small part in which he feels a vital interest, might be disposed to criticise such a classification as unnecessarily complicated and as implying a more extended knowledge of general geology than he usually possesses; but for the teacher and the student of economic geology and all who care for broad views over this field, it would possess obvious advantages.

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*A paper presented before the Geological Society of America, Dec. 29, 1893.

It is generally conceded that, whatever the limits of the classification, its highest value, both as a means of education and as an aid in the discovery and exploitation of deposits, demands that it should be essentially geological, and not be based, at least in its main lines, upon the qualities or uses of the materials. Now, geology is, first of all, a dynamical science; and, as professor Kemp has shown,* there are cogent reasons for basing a classification of economic deposits upon origin instead of structure. The genetic principle, so universally recognized as the basis or key-note of biologic classifications, is slowly but surely making its way in the domain of geology. Classification by structure, of which form is but the external expression, is less difficult, and hence has generally prevailed in the early days of each science. The main reason why the recognition of the genetic principle has made, relatively, so little progress in geology, is that the processes, being to a large degree chemical, are often exceedingly obscure; and the correct interpretation of the observed facts of composition and structure is hence peculiarly difficult. Our knowledge is, in consequence, decidedly insufficient, in certain directions, for the detailed application of this principle of classification. It is, for example, the general belief of geologists that mineral veins have been formed chemically, that is, by the deposition of minerals from solution; but further than that, as a rule, we cannot safely go; for the nature of the chemical process in particular cases is still a matter of speculation rather than of positive knowledge. The recent literature of the science shows, however, that light is breaking upon this problem in various directions, and we may hope for a better state of things in the near future.

It appears, then, that while differences of structure and composition must always be recognized in our classifications, they will become relatively less important with increasing knowledge of genetic processes. In this connection we may properly draw a sharp distinction between original and subsequent structures, the former alone having classificatory value. The validity of this distinction is apparent on referring to the biologic sciences, since, for example, the accidental loss of one or more of its rays by a starfish does not affect its position in the classification. Of course, changes in geologic deposits amounting to complete metamorphism, to the transformation of one type into another, are truly original and genetic, and not in any sense accidental, with reference to the new type. Thus superficial oxidation may be neglected in the classification of veins, but it is highly important as defining one type of residual deposits. Distinctions based directly upon composition should be subordinate, in the main, to original structural distinctions, and hence can be generally recognized only in a more complete and detailed classification than is possible in the present state of our knowledge. Even a classification based upon origin and original structure, such as is attempted here, is necessarily in advance of our knowledge, in the sense that future investigations, in many cases, must decide to which sections particular deposits should be referred.

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*Ore deposits of the United States, p. 42.

Many classifications of ore deposits have been published; and the more important of these have been recently summarized and compared by professor Kemp, in the introduction to his valuable work on the ore deposits of the United States. But, since metalliferous minerals or ores constitute simply one limited division of the whole field of economic geology, it is apparent at a glance, after what precedes, that these classifications must be, without exception, seriously lacking in scientific and educational value. They may be said, perhaps, to meet, in some degree, the needs of the metallurgist; and in a measure, also, those of the miner. But coal and many other non-metalliferous minerals are extensively mined and occur in characteristic deposits, with the forms and modes of origin of which the miner should be acquainted.

The distinction of rocks (igneous and sedimentary formations) and mineral deposits (veins, impregnations, etc.), or, as it is commonly stated, original and secondary deposits, or unconcentrated and concentrated mineral deposits, is deemed of great importance by some authorities, and notably, among the more recent writers, by Posepny, who has introduced the terms idiogenous and xenogenous to designate these two classes. It seems to the present writer, however, that in a broad view of the field this distinction disappears or becomes of subordinate importance.

Strictly speaking, nearly all, if not quite all, known rocks are secondary. This is generally conceded for the sedimentary rocks; but, following Iddings and other recent writers, it must be admitted also for the igneous rocks. A dike is a more or less highly differentiated portion of some deep-seated magma, and it is clearly newer than the walls. An ascensionist, certainly, can say nothing more for a vein save that while in formation of the dike heat is the chief agent, with water coöperating (aqueo-igneous fusion), in the formation of the vein water is the chief agent, with heat coöperating (igneo-aqueous solution). The greater mobility of the solution permits a higher degree of concentration, but concentration is a universal process and participates in the formation of eruptive masses and sedimentary deposits, as well as of veins. In other words, solidification and deposition, or the rock-making processes, involve in every instance differentiation and concentration; while liquefaction, or the destruction of rocks, whether aqueous or igneous, implies just as universally the undoing of differentiation or dissipation of matter. It appears illogical, therefore, to regard one class of rocks (vein rocks) as fundamentally distinguished by the fact that their formation involves the concentration of their component minerals. The concentration is quite as marked in the formation of a bed of sand, clay, limestone, gypsum, chert or iron ore; and, if less marked, it is certainly not less true in the formation of a dike of granite or trap. In the opinion of the writer, no sharp line of demarcation can be drawn between dikes and veins, and veins are clearly entitled to some degree of recognition in the lithological classification. In a broad view of the early history of the earth all the sedimentary rocks are, of course, secondary with reference to the primitive igneous crust, but so are the igneous rocks with which we are now acquainted. Probably none of the igneous which have been studied are truly primitive; and their derivation in some cases from sediments is claimed by many able observers.

Veins and dikes are newer than both walls, lava flows and sedimentary strata are newer, always, than one wall and older than the other. But, for the reasons already stated, the primary distinctions should be genetic rather than structural, although here, as generally, a close correlation of genesis and structure is to be noted. Heat and water are the two great agents concerned in the modification and differentiation of the earth's crust; and they are generally, if not everywhere and always, in coöperation, heat prevailing, as a rule, at great depths, and water at the surface. Thus arise the two principal classes of rocks—igneous and aqueous. In either class the rocks may be deep-seated (newer than both walls), or superficial (newer than one wall), in other words, intrusive or contemporaneous. The intrusive igneous masses are known as dikes, etc., and the contemporaneous as lava-flows; while the intrusive aqueous masses are known as veins, etc., and the contemporaneous as sedimentary strata.

Subterranean aqueous deposition must always take place from solution, or in a purely chemical manner; but superficial aqueous deposition may take place from suspension (mechanically), or from solution (chemically), or through the agency of organic matter (organically); and these are undoubtedly, as generally recognized, the natural subdivisions of the superficial aqueous rocks, standing secondary to the distinction of superficial and deep-seated deposits. In several published classifications of ore deposits, however, the primary divisions of the aqueous deposits are based upon the nature of the formative process, whether mechanical or chemical. In other words, the first question asked concerning any type is, was it deposited from suspension or solution? and not, was it in its origin superficial or deep-seated? The disadvantage of this plan becomes apparent as soon as it is extended to embrace all economic deposits or to have approximately natural boundaries; for it associates deposits having little in common, and disassociates those that are closely related. Thus, a bed of gypsum and a vein or impregnation, say of tin ore, are, according to these classifications, more nearly related, since both are chemical deposits, than a bed of gypsum and a bed of slate. This may be true from the standpoint of a chemist, but it is certainly not good geology; for whether we are considering the relations of the deposits to each other or their general relations to geological history, gypsum stands naturally much nearer to slate than to tin ore; and genetic, structural, and economic considerations all demand that superficial and deep-seated deposits should not be commingled.

In the opinion of the writer, we have good reason to believe that fusion and solution are not only continuous and overlapping processes, but that giant granite or pegmatite may be regarded as marking the halfway point, the product of their perfect coöperation. Pegmatite combines the characters of plutonic and vein rocks, but does not belong distinctly to either class, demanding separate recognition and classification.

EXPLANATION OF THE CLASSIFICATION.

The classification embraces, as the table shows, three primary and coördinate divisions, as follows:—

A. Deposits of igneous origin (igneous rocks). Heat is the chief agent.
B. Deposits of aqueo-igneous origin (giant granite or pegmatite). Heat and water coöperate.
C. Deposits of aqueous origin (sedimentary and vein rocks). Water is the chief agent.

These main divisions of the classification may now be considered separately, and their subdivisions noted, with illustrative examples of each type, so far as such have been clearly recognized. Many of the examples, it should be added, have been taken directly from Kemp's "Ore Deposits of the United States;" and his interpretation of the facts have, in most cases, been accepted without further investigation.

A. *Deposits of igneous origin.*—Following the lines of the lithological classification, we may divide the igneous rocks into the intrusive or plutonic rocks and the extrusive or volcanic rocks; although this distinction is obviously not of paramount importance on purely economic grounds. These two great classes of igneous rocks admit, for economic purposes, parallel subdivisions, as follows:

1. Igneous deposits of subterranean origin (plutonic rocks). Among the plutonic rocks we may recognize:

(a) *Normal plutonic rocks*, altered and unaltered. These are useful especially as affording materials for construction (building and ornamental stones, etc.); but they have in the aggregate, by virtue of their abrasive, refractory and other qualities, a wide range of applications in the arts.

(b) *Highly differentiated and excessively basic plutonic rocks.* These are peridotites and other ultra-basic rocks, in which, through the operation, we may suppose, of Soret's principle, as Iddings insists, aided, possibly, by magnetism and gravitation, as suggested by Vogt, the metallic oxides or free bases (magnetite, menaccanite, etc.), which occur only as relatively unimportant accessories in the normal types, become highly concentrated and give character to the rock, constituting a very distinct and not unimportant type of iron ore. The dike or stock of titaniferous magnetite, with accessory olivine and feldspar, of Cumberland, R. I., is a good example; and these ores have also been recognized in the Adirondacks, Minnesota, Brazil, and Scandinavia. It appears, in fact, that the highly titaniferous, crystalline iron ores should be, in general, referable to this type.

(c) *Original disseminations in plutonic rocks.* Not the rock as a whole, but a single original constituent, is useful. The useful mineral may be accessory, as the zircon in certain syenites; or essential, as the chatoyant labradorite of certain norites and gabbros. This type is not markedly different from the preceding (b). Only one constituent or class of constituents is, strictly speaking, useful in each case; but the magmatic concentration is an essential feature of (b) and the entire rock or ore must be mined and submitted to metallurgical treatment. The last consideration savors somewhat of a classification by uses, and the chief emphasis should, therefore, be laid upon the concentration of (b) as the more essential distinction.

Each of these types (a, b, c) may theoretically, at least, occur in or form—(1) dikes, (2) intrusive sheets or sills, (3) laccolites, (4) stocks or plugs, bosses and complexes.

(d) *Sublimates* formed in dry fissures or other cavities, and not necessarily in plutonic rocks; although heat, of course, is still the chief agent. This type—virtually veins formed by sublimation—is proposed with hesitation. Sublimation is at the present time, and justly, in marked disfavor as a general explanation of mineral veins. Below the permanent water-level the vacant fissures essential to the formation of sublimates must be non-existent; and subterranean sublimation deposits, if occurring at all, must be limited in depth; while the composition and structure of most veins are best explained by deposition from solution. On the other hand, the varied and abundant sublimates formed on the surfaces and in the cracks of recent lavas make it more than probable that, at least in the neighborhood of volcanic vents, they extend to a sufficient depth to deserve classification among subterranean deposits; and we may safely conclude that sublimation is a true, though not a principal, cause of vein-formation. This conclusion is sustained by the fact that a large proportion of the vein-forming minerals have been produced experimentally by sublimation. Although accepting the sublimation theory as a valid explanation within the narrow limits indicated, I am unable to cite positively any economic deposits as examples under this head; but there seems to be a fair probability that such exist.

II. Igneous deposits of superficial origin (volcanic rocks). Similarly the volcanic rocks include:

(a) *Normal volcanic rocks or lavas* (including tuffs), ancient and modern. These, like the corresponding plutonic rocks, are useful chiefly for structural purposes; but it is sufficient to cite pumice to indicate that they also have other uses.

(b) *Highly differentiated and excessively basic volcanic rocks.* The conditions are undoubtedly less favorable for the development of the igneous iron ores in lava flows than in plutonic masses; but this type is proposed in the belief that this occurrence is not impossible. In fact, it might almost be claimed that we have an example in the huge masses of native iron in the basalt of Ovifak.

(c) *Original disseminations in volcanic rocks.* The crystals of peridote (olivine) and various other gems occurring as original, and usually as accessory, constituents of lavas clearly justify this feature of the classification.

Each of these three types (a, b, c) may occur in or form—(1) contemporaneous sheets or flows; (2) volcanic cones; (3) volcanic pipes or necks.

(d) *Sublimates* on recent lava, in solfataras, fumaroles, etc. The abundant occurrence of sulphur, boracic acid, and other minerals of economic interest in and about volcanic craters establishes the validity of this type.

B. *Deposits of aqueo-igneous origin.*—The arguments for the separate recognition in the lithological classification of the aqueo-igneous rocks or pegmatites have been stated with sufficient fullness. Their economic importance is manifest when we reflect that they are the principal source of quartz, feldspar and mica for commercial purposes, that they contain important deposits of tin ore, and that they afford tourmaline, beryl, and other valuable gems.

C. *Deposits of aqueous origin.*—The aqueous deposits embrace, as already explained, both those of subterranean origin (vein rocks, etc.) and those of superficial origin (sedimentary rocks, etc.).

I. Aqueous deposits of subterranean origin (vein rocks, etc.).—These have necessarily been formed by deposition from solution; but, although they are in general vein-like, and are as a class commonly called veins, it appears to the writer that in a classification based upon origin three main divisions should be recognized, as follows: Veins, or deposits in pre-existing cavities; impregnations, both metasomatic and non-metasomatic; and substitution deposits, or complete metasomatic replacements.

1. Veins, or deposits in pre-existing cavities.—The line of demarcation between impregnations and substitution deposits is, in the nature of the case, less sharply defined than that between either of these classes and veins, since metasomatic impregnations must grade into complete replacements. A pre-existing cavity or free, continuous space is regarded as essential to the formation of a vein; and all deposits in such cavities, without regard to the forms or modes of origin of the cavities, are here classed and described as veins. It should be noted, however, that the cavities are usually, if not always, secondary features of the wall-rock, the product in general of displacement, plication, shrinkage, or solution. The only important instance, so far as I know, of cavities contemporaneous with the walls, which might conceivably become the seats of veins, is afforded by the lava tunnels which are a somewhat important feature of the Hawaiian and some other volcanoes. It seems extremely probable that cavities formed in this way have in some instances been filled by deposition from solution; but so far as I am aware this mode of occurrence has not been demonstrated, at least not for any economic deposits, although it is well known that the chimney form, which this origin would require, has been clearly recognized in certain ore deposits. The discovery of an undoubted instance of such a volcanic vein of economic interest would necessitate a fundamental distinction between veins filling original and those filling secondary cavities, all the types of veins recognized in this paper belonging to the second class.

True veins are, of course, always to be reckoned as structural rather than textural features of the formations which they traverse; and interstitial deposits, due to the filling of steam holes and other forms of interstices, are types of impregnations and not of veins. It may be noted, however, that the larger steam holes pass gradually into irregular cavities of considerable size, which are also often filled with segregations of chalcedony, etc., and clearly point to the possibility of veins in lava tunnels.

The following classification of veins formed in secondary cavities is based upon the modes of origin, and only incidentally upon the forms of the cavities or fissures; but it is clearly recognized, as already pointed out, that with increasing knowledge of the chemistry of vein formation the mode of filling will take precedence as a basis for the classification, the present arrangement being regarded as provisional. Not only the character of the mineral solutions, but their sources, whether descending, lateral (lateral secretion veins), or ascending, should be considered in the true classification of veins. The advocate of either source to the exclusion of the others ought to appear as archaic now as would an out-and-out plutonist or neptunist: for this is the day of the recognition of the kernel of truth in every theory. We are recognizing more and more clearly that nature has worked in diverse modes to the same general end, and that a complex class of phenomena cannot, as a rule, be referred to a single simple cause. Posepny has properly emphasized the distinction between the superficial and the deep-seated aqueous circulation, and he is undoubtedly right in relegating the phenomena of vein formation chiefly to the domain of the latter. But in his enthusiasm as an ascensionist he has probably gone too far and referred to ascending currents deposits that may be more readily explained by lateral secretion or descending currents.

During the filling of a cavity, the mineral solutions may or may not penetrate and impregnate the walls; and this impregnation, when it occurs, may or may not be metasomatic. Thus the same continuous deposit may combine a vein and an impregnation, or a vein and a substitution deposit, or all three; and the vein is in many cases the least important part of the combination, having simply supplied a channel for the impregnating and replacing solutions. Similarly veins may or may not occur on or near igneous contacts, although, as others have pointed out, all deep veins are contact deposits with reference to the igneous interior of the earth. These distinctions, as well as the source and nature of the solutions, and the mode of origin of the cavities, should be recognized in a complete and detailed classification of veins. But it is deemed sufficient to simply refer to them here, and thus, incidentally, to explain the absence from the outline scheme here proposed of the so-called contact veins.

In a classification of veins filling secondary cavities in accordance with the mode of origin of the cavities, it is of the first importance to distinguish sharply, as Posepny has done, between the cavities formed by mechanical forces (spaces of discission) and those formed by chemical forces (spaces of dissolution). Of the eight types of veins described in the following pages, six belong to the first category and two to the second.

(a) *True fissure veins*, filling profound fissures, which are usually accompanied by displacement (fault fissures). This is the leading type of veins and is so recognized in the standard text-books of geology. When the fissures can be proved to coincide with important displacements, permanence in depth is reasonably assured and filling by ascending currents may be regarded as highly probable. Slickensided walls and a distinct selvage are very characteristic features, though by no means essential or peculiar. Important examples are so numerous as to make citation or further description unnecessary.

(b) *Crushed-zone or shear veins*, filling crushed or shear zones along faults or lines of shearing stress. These are often equivalent to fissure veins filled with fragments of the wall-rock; and in other cases the crushing may take the form of a more or less distinct sheeting. The crushed or sheeted rock is frequently extensively impregnated or replaced by the vein matter; and the enclosure of the fragments is often so dike-like that the vein matter has, even by some recent writers, been regarded as of igneous origin. The veins of this type are commonly without definite boundaries or walls, and sometimes pass into more or less typical stockworks. The normal form of the deposit, when not sheeted, is believed to be approximately or roughly lenticular; and it is probable that one great lens may succeed another in strike or depth along an extended line of fracture. This localization of the crushing may, apparently, be regarded as a necessary result of a shearing stress along a highly irregular or somewhat interlocking fracture, the protruding or convex portions only of either wall being crushed by the enormous friction. Among the more important deposits believed to be referable to this type are the nickel ores of the Sudbury district, Ontario, and the Gap mine, Pennsylvania.

(c) *Joint or gash veins*, filling joint-cracks, or fissures due to (1) shrinkage and (2) vibratory and torsional strains, and (3) transverse fissures due to plication and warping without faulting. This type, with varying definition, has been recognized in several classifications of veins. It is, of course, not always sharply distinguished from the true fissure veins. The chief points of difference are, that faulting is more commonly absent and when occurring is less extensive, that the veins are more limited in length and depth, that slickensided walls and a true selvage are more commonly wanting, and the filling is more likely to have been by lateral secretion. Like joint-cracks, the gash veins are frequently intersecting (reticulated veins) and often exhibit the stock-work phase. In fact, reticulated veins and veinlets, or stockworks, although a phase, also, of shear veins, may be regarded as in the main a sub-type of the gash veins. In calcareous rocks, the cracks have been very generally enlarged by solution, before filling; and in both calcareous and siliceous rocks impregnation and replacement of the walls are of common occurrence. The transverse fissures due to plication, here referred to gash veins, are likely to be limited in depth, and to differ from ordinary joint-cracks, chiefly in the divergence of the walls, diverging downwards in synclinal cracks and upwards in anticlinal cracks. Among the many more or less typical examples of gash veins which might be cited are the following: the auriferous pyrite and chalcopyrite veins of Gilpin county, Colorado; the veinlets of native copper in felsite, Santa Rita, N. M.; and the lead and zinc deposits of the Mississippi valley, which take the form chiefly of gash veins and flats, the flats being in part horizontal gash veins. As examples of stockworks in this country, we have the Black Copper group, Globe district, Arizona; the zinc deposits of the Saucon valley, Pennsylvania; the lead-silver deposits in the dolomite of Aspen mountain, Colorado; and, in part, the quicksilver deposits of New Almaden, California.

(d) *Interbedded veins*, filling rifts between the strata, *i. e.*, fissures parallel with the strata and due to plication. Although the close relations of this type to the gash veins are very obvious, its distinctive features are so strongly marked as, in the opinion of the writer, to justify its separate recognition. In fact no type of vein possesses more definite characteristics or is more readily identified. As a rule, they conform closely or perfectly with the strata in strike and dip, present in many cases remarkably smooth and well-defined walls, without indications of slipping, and from the nature of the case they must be limited in depth. The essential thing is that they are rifts due to plication, for of course true fissure veins (a) may conform with the strata superficially. Tarr, in his recent and comprehensive work on the "Economic Geology of the United States" (p. 90), seems to consider that for veins of this type there were no pre-existing fissures, segregation commencing along a bedding plane, and the deposit as it grew crowding back the rocks and making room for itself, much as a concretion or a root might. That this is a possible explanation I am ready to believe, for I have observed something analagous in the veinlets of gypsum traversing anhydrite in the gypsum quarries of Windsor, Nova Scotia. But I have no reason to suppose that this action would be any more efficient in the bedding planes than along joint or other cracks transverse to the bedding, and rifts between the strata are unquestionably a natural result of the folding of thin-bedded rocks; although the two causes might, of course, coöperate. If these truly concretionary veins should prove to be important or of economic interest it would become necessary to make a fundamental distinction in the classification between endogenous veins (formed in pre-existing cavities) and exogenous veins (formed, like concretions, in the solid rock). As examples of interbedded veins, we have the auriferous quartz veins of Nova Scotia, California, and other districts; the great lenticular veins of pyrite along the Appalachian belt: the lenses of specular hematite on the James river in Virginia; and possibly some of the great lenses and sheets of magnetite belong here.

(e) *Neck veins*, filling the interstices of agglomerates in volcanic pipes or necks. This is a recently, but not quite generally, recognized type, based upon the Bassick and Bull Domingo silver mines near Rosita, Colorado. These ore bodies or deposits are chimneys 20 to 100 and 40 to 60 feet in horizontal section, in andesite and in Archean gneiss, respectively, filled chiefly with fragments of the wall-rock; and between, over, and replacing these fragments, the deposition of the ores has taken place. This mode of occurrence is, *a priori*, so probable that we may fairly suppose that other and more important examples have been overlooked or misinterpreted. The resemblance of this type to the lenticular crushed or shear veins is quite marked, and when we consider that, as in these cases, the necks of the craters and craterlets are naturally elliptical in outline and tend to occur in linear series along lines of fissure, the need of proceeding cautiously in distinguishing these two types is obvious.

(f) *Crenitic veins*, filling the conduits of thermal springs. This type, which so far as I know, is proposed here for the first time, is suggested by the deposits of silver-lead ores of Red mountain, Ouray county, Colorado. The deposits traverse the mountain in an irregular way and are believed to mark the courses of old hot spring conduits. The wall-rock is silicified andesite, having been highly altered by the ancient thermal waters. This type differs from the true fissure veins much as a volcanic neck differs from a typical dike, *i. e.*, the ascending ore solutions are more localized, and it is perhaps possible that at greater depths these conduit deposits pass into normal fissure veins. Believing as we do that mineral springs have played an important part in the formation of veins, the only occasion for surprise is that these crenitic veins have not been more frequently identified and described; and it will be recalled that Sandberger finds here one of his chief arguments against the theory that veins are formed by ascending currents. It is probable that the conduits have, in most cases at least, been somewhat enlarged and modified in form by solution prior to filling. This assumption would be particularly safe when the wall-rock is limestone; but such modification must evidently be equally common with gash veins and other types having the normal sheet form. The cavities of mechanical and of chemical origin are thus combined, but gradation and transition forms are the rule everywhere in geology, and veins are no exception.

(g) *Cavern veins*, filling cavities due to solution, including chambers, flats, sheets, pitches, etc. This is the principal type of veins filling spaces of dissolution. On *a priori* grounds it has strong claims to recognition. Solution cavities or caverns are numerous, especially in limestones above the drainage level; and we often observe them in process of filling, especially with stalactite and stalagmite deposits. The chief difficulty is to find undoubted examples of economic interest; nearly all the deposits formerly referred to this type having been proved on more careful study to be replacements. As more or less probable examples I may cite the celebrated Cave mine of Beaver county, Utah; some of the lead and zinc deposits of the Mississippi valley (enlarged gash veins); and a series of small caves near Ouray, Colorado, in quartzite overlain by shales and containing native gold.

(h) *Brecciated cavern veins*, filling collapsed or brecciated beds resulting from solution, dolomitization, or some other chemical change. This type is related to the last very much as the shear veins are to the true fissure veins. Particular strata of limestone are weakened by the solvent action of percolating water, they collapse and become brecciated, and between and around the fragments thus resulting the vein minerals are deposited. It is obvious that metasomatic replacements might not be readily distinguished from deposits of this type. Among the actual occurrences supposed to belong here are the specular hematite of Crawford county, Mo.; the copper ore of St. Genevieve, Mo.; the lead and zinc deposits of the upper Mississippi valley (in part), including the lower flats and tumblers of Chamberlin; and the zinc deposits of southwestern Missouri.

2. Impregnations, or deposits filling the pores and often replacing the original or normal constituents of various rocks (metasomatosis).—Although second only, in importance, to veins, this main type of aqueous deposits may be more briefly described. Certain types of impregnations occur chiefly, as already explained, in the walls of veins, the fissure having afforded a passage for the impregnating solutions in each case. Also, impregnations, like veins, may or may not occur along igneous contacts. In the subdivisions of impregnations we may properly distinguish the concretionary, pore-filling but not concretionary, and metasomatic but not concretionary, types, as follows:

(a) *Concretionary deposits that are not metasomatic—impure concretions*, due to the segregation of a soluble constituent in a siliceous or otherwise insoluble rock. The segregating minerals are chiefly carbonates (calcite, etc.) and the carbonate or other soluble salts of iron from which the iron is often deposited as the insoluble oxides. Being unable to remove the siliceous matrix, the segregating minerals are deposited in it, more perfectly cementing the particles of clay, grains of sand, etc. The common claystone is a familiar example of these impure concretions—combinations of concretion and matrix; and clay ironstone may be named as the chief economic example.

(b) *Concretionary deposits that are metasomatic—pure concretions*, due to the segregation of a soluble constituent in a soluble or metasomatically replaceable matrix. The siliceous concretions of calcareous rock (flint and chert nodules, geodes, etc.) are clearly the most important examples, and no more distinctly economic examples have occurred to me;

but this type may fairly be retained to preserve the symmetry of the classification. It should be noted that the essential idea of an economic concretionary deposit is that, although the segregating mineral is an original constituent of the rock, the segregation is required to make it available (concrete) and useful. If the rock, as a whole, is useful, as in the case of oölitic limestone and iron ore, it must be differently classified. Clay ironstone is separated from black-band ore in the classification simply because segregation is essential to make the iron carbonate useful, to change it from a rock to an ore; and the ore only and not the entire rock is used.

(c) *Amygdaloidal deposits*, filling the pores (steam-holes) of igneous (volcanic) rocks. This familiar type requires no detailed explanation. The most important example is, of course, the cupriferous amygdaloid of Keweenaw Point; to which may be added the cupriferous felsite of Santa Rita, N. M., although the supposed amygdules may be only pseudo-amygdules or actual replacements, filling secondary cavities, which would refer the deposit to the metasomatic impregnations.

(d) *Interstitial deposits*, filling the pores (interstices) of sedimentary rocks. The designation of this type, although not, perhaps, wholly unobjectionable, is the most satisfactory that has occurred to the writer. It is intended to include all those cases where sedimentary rocks have been filled but not replaced by economic amounts of useful minerals. It is very probable, however, that in many cases, as in the cupriferous conglomerate of Keweenaw Point, the interstitial filling is accompanied by true metasomatic replacement. As additional examples of this type, we have the cupriferous sandstones of the Copper Basin, etc., Arizona, and of various localities in Texas, New Mexico, Utah, etc.: the silver-lead, apparently non-metasomatic, deposit in quartzite of Coeur d'Aléne, Idaho; the Potsdam sandstone of the Black Hills impregnated with auriferous pyrite, which may be oxidized; and the argentiferous Triassic sandstone of the celebrated Silver Reef mine, Utah.

The non-concretionary metasomatic impregnations may be conveniently subdivided in accordance with the nature of the impregnated rock, as follows:

(e) *Metasomatic deposits in calcareous rocks.* The Clinton iron ores appear to be, in part, limestone replaced by ferric oxide. The deposits of galenite and nickeliferous pyrite of Bonne Terre, Mine la Motte, and Doe Run, Mo., are local enrichments (impregnations) of limestone; and the silver ores of Glendale, Montana, and Wood River, Idaho, clearly belong under this type. According to Kemp's recent and able summary of our knowledge of the extensive and unique deposits of oxidized zinc ores at Franklin Furnace* and Ogdensburgh, N. J., they are most probably interbedded impregnations.

(f) *Metasomatic deposits in fragmental rocks.* Some of the native copper of Keweenaw Point belongs here; and the copper ores near the trap sheets in the Triassic sandstone of New Jersey not only impregnate, but, apparently, actually replace the sandstone.

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*Trans. N. Y. Acad. Sci., XIII, pp. 76-98.

(g) *Metasomatic deposits in igneous rocks.* The first examples noted occur in volcanic rocks, and the later ones in plutonic rocks. In the cupriferous amygdaloid of Keweenaw Point the copper is in part a true replacement of the diabase. The auriferous quartz of the Little Annie mine, Rio Grande county, Colorado, is probably a silicified rhyolite. At Silver Cliff, Colorado, rhyolite is impregnated with cerargyrite, and in the Calico district of California liparite and tuff are similarly impregnated. The copper deposits of Llano county, Texas, are partly fissure veins, but chiefly true impregnations in granite. The copper ores of the Morenci district, Arizona, are in part impregnations of the porphyry in which they occur. Many of the gold and silver deposits of the Rocky mountains, etc., are metasomatic impregnations of dikes and plutonic masses. The tin deposits of Irish Creek, Va., are typical impregnations of granite among leaders (veinlets) of quartz.

(h) *Metasomatic deposits in metamorphic rocks* (*gneisses and schists*). These deposits, when conforming with the bedding or foliation, constitute the typical *fahlbands*; and are then not easily distinguished from original sedimentary deposits on the one hand, and interbedded veins on the other. Besides the classic example, the argentiferous fahlbands at Kongsberg, Norway, which are of economic interest only at their intersections with a series of veins, we may notice one important American locality. The great pyritiferous bed (superficially oxidized) of the Homestake mine and other similar beds in the Black Hills, are either original or secondary (true) fahlbands. If the pyrite is a part of the original sedimentary deposit, the subsequent changes—crystallization and segregation—have probably been sufficiently extensive to justify the present classification.

3. Substitution deposits, or complete metasomatic replacements.—Through the recent labors of Dr. S. F. Emmons and others, the substitution deposits have been proved to be of great importance; and many deposits formerly classed as veins are now known to be complete metasomatic replacements. Metasomatic impregnations may be regarded as marking, in general, the halfway point in the development of substitution deposits; although in calcareous rocks the impregnation stage can not be regarded as essential, the contact between the ore body and the limestone being often sharply defined. Like impregnations, the substitution deposits may or may not occur in the walls of veins or along igneous contacts. Substitution deposits may be divided in the same way as impregnations; but since they present comparatively little commingling of rock and ore, it is sufficient for our purpose to recognize two subtypes, as follows:

(a) *Substitution deposits in calcareous rocks.* The important examples are too numerous for detailed citation, but include the following: The copper deposits, in part, of the Morenci, Bisbee, and Globe districts of Arizona, and of the Santa Rita district, New Mexico; and the lead-silver ores of the Leadville, Ten Mile, Monarch, Eagle River, Aspen, and Rico districts, of Colorado; of Galena and Carbonate, South Dakota; of Bingham, and Big and Little Cottonwood Cañons, the Crismon-Mammoth vein and the Horn Silver mine, Utah; and of the Eureka and White Pine districts, Nevada.

(b) *Substitution deposits in siliceous rocks.* Owing to the greater insolubility of the rocks, the well-identified examples under this type are less extensive, but include the following: The hematite of the Penokee-Gogebic district and the Mesabi range, and possibly of Iron Mountain, Mo.; the copper ores of Butte, Montana (extensive replacements of granite along small fissure veins); the veins of native copper on Keweenaw Point; and many so-called gold and silver veins, including the Comstock lode.

II. Aqueous deposits of superficial origin (sedimentary rocks, etc.).—The history of the superficial aqueous deposits is so much less obscure than that of the subterranean deposits that comparatively brief statements will suffice. Following the order of the lithological classification, we have:

1. Mechanical deposits (fragmental rocks).—These have been deposited from suspension, and include:

(a) *Normal fragmental rocks,* including the conglomerate, arenaceous, and argillaceous groups, consolidated and unconsolidated.

(b) *Placer deposits,* fluvial and marine, ancient and modern. The sorting action of water has effected the concentration in the rock, at the time of its deposition, of one or more useful minerals, such as gold, platinum, iridosmine, cassiterite, and magnetite, and corundum, topaz, diamond and other gems. This type may be compared with the original disseminations in igneous rocks, a single constituent and not the entire rock being useful. It is quite unnecessary to cite the numerous gold placer districts of this country. Marine placers occur at Port Orford, Oregon, and Yakutat bay, Alaska. The gold placers of the Black Hills are in part Quaternary and Recent, and in part the basement beds of the Potsdam sandstone. The beds of conglomerate iron ore mantling Iron Mountain and Pilot Knob, Mo., show the sorting and concentrating action of water and are virtually ancient placers.

2. Chemical deposits (chemically-formed rock, etc.).—These have been deposited from solution by:

(a) *Oxidation.* The examples include: Bog limonite, with pond and lake ore; Clinton hematite, oölitic ore, due to deposition of iron oxide in concentric coats about minute grains of quartz; and fossil ore, where the iron oxide is deposited in or replaces waterworn fragments of calcareous organisms; beds of limonite and red hematite in various formations from the Cambrian to the Tertiary; the specular hematite of the Marquette and Menominee districts (probably); the Vermilion lake hematite, believed by Profs. N. H. and H. V. Winchell to be a marine chemical precipitate; the great bed of specular hematite on Pilot Knob, Mo. (probably); bauxite and many manganese deposits.

(b) *Reduction.* The chief agent is organic matter, and under its influence the soluble sulphates yield native sulphur and various metallic sulphides. Sulphide of iron is extensively deposited in this way in argillaceous sediments; and it may be that some of the great beds and lenses of pyrite have had this origin.

(c) *Evaporation.* The chief examples are siderite (black-band, etc.), calcareous and siliceous tufas, gypsum, rock salt, etc. The tufas would be of special interest in a more detailed study as marking the overflow portions of subterranean solutions which formed veins and impregnations on their way to the surface.

3. Organic deposits (organically formed rocks, etc.).—These have been formed by the accumulation of:

(a) *Hydrocarbons*, giving rise to coals, bitumens, etc.

(b) *Siliceous organisms*, giving rise to tripolite, etc.

(c) *Calcareous organisms*, giving rise to limestones.

(d) *Phosphatic materials*, giving rise to guano and phosphate rock.

4. Metamorphic deposits.—Either of the above groups (1, 2, 3), under the combined influence of water, heat, pressure, and chemical change, may become metamorphic (crystalline), affording thus:

(a) *Normal metamorphic rocks*, where the rock as a whole may be useful (some of the crystalline iron ores belong here); and

(b) *Original disseminations in metamorphic rocks*, where crystallization has developed in the rock minerals (usually accessory, such as garnet and pyrite) which may be of economic interest.

5. Residual deposits.—These are due to superficial chemical changes (oxidation, hydration, etc.) and commonly to differential chemical erosion. Two principal types may be recognized, as follows:

(a) *Oxidized and partially oxidized, and residuary metalliferous deposits* (including gossan). The chief examples are the residuary ores of iron and manganese, including the limonite deposits of the Great Valley, the great deposit of magnetite at Cornwall, Pa., being, perhaps, a metamorphic example of one of these. The Clinton ore (hematite) is due, in part, to the differential erosion of ferriferous limestone.

(b) *Residuary earthy and siliceous deposits*, including a large proportion of the ordinary superficial detritus or soil and some phosphate deposits, kaolin being the most important single example.

In conclusion, it may be noted that it is not a valid argument against this or any classification that our ideal types are far simpler, in most cases, than the actual deposits; for a classification, to have any value, must isolate causes and exhibit phenomena in their elements. Thus, for example, actual veins are usually combined with impregnations and replacements, and on the surface mechanical, chemical, and organic deposition go hand in hand; and we can not ordinarily say of a deposit that it belongs to this or that type, but to this or that combination of types.

Outline of the Classification.

A. Deposits of igneous origin (igneous rocks).
  I. Igneous deposits of subterranean origin (plutonic rocks).
    (a) Normal plutonic rocks.
    (b) Excessively basic plutonic rocks.
    (c) Original disseminations in plutonic rocks.
    (d) Sublimates in fissures.
  II. Igneous deposits of superficial origin (volcanic rocks).
    (a) Normal volcanic rocks or lavas.
    (b) Excessively basic volcanic rocks.
    (c) Original disseminations in volcanic rock.
    (d) Sublimates on lava.
B. Deposits of aqueo-igneous origin.
C. Deposits of aqueous origin.
  I. Aqueous deposits of subterranean origin (vein rocks, etc.).
    1. Veins, or deposits in pre-existing cavities.
      (a) True fissure veins.
      (b) Crushed-zone or shear veins.
      (c) Joint or gash veins.
      (d) Interbedded veins.
      (e) Neck veins.
      (f) Crenitic veins.
      (g) Cavern veins.
      (h) Brecciated cavern veins.
    2. Impregnations.
      (a) Concretionary deposits, not metasomatic.
      (b) Concretionary deposits, metasomatic.
      (c) Amygdaloidal deposits.
      (d) Interstitial deposits.
      (e) Metasomatic deposits in calcareous rocks.
      (f) Metasomatic deposits in fragmental rocks.
      (g) Metasomatic deposits in igneous rocks.
      (h) Metasomatic deposits in metamorphic rocks.
    3. Substitution deposits.
      (a) Substitution deposits in calcareous rocks.
      (b) Substitution deposits in siliceous rocks.

- II. Aqueous deposits of superficial origin (sedimentary rocks, etc.).
  - 1. Mechanical deposits (fragmental rocks).
    - (a) Normal fragmental rocks.
    - (b) Placer deposits.
  - 2. Chemical deposits (chemically formed rocks, etc.).
    - (a) Oxidation deposits.
    - (b) Reduction deposits.
    - (c) Evaporation deposits.
  - 3. Organic deposits (organically formed rocks, etc.).
    - (a) Hydrocarbons.
    - (b) Siliceous rocks.
    - (c) Calcareous rocks.
    - (d) Phosphatic rocks.
  - 4. Metamorphic deposits.
    - (a) Normal metamorphic rocks.
    - (b) Original disseminations in metamorphic rocks.
  - 5. Residual deposits.
    - (a) Residuary metalliferous deposits.
    - (b) Residuary earthy and siliceous deposits.

GEOLOGY OF JEFFERSON COUNTY, TEXAS.

W. Kennedy, Austin, Texas.

Early last spring (1893) a company was formed at Beaumont in Jefferson county, Texas, with the ostensible purpose of exploring for natural gas, oil and sulphur, supposed to exist in great quantities in that portion of the state.

Jefferson county lies in the extreme southeastern corner of the state. The Neches river and Sabine lake form its eastern boundary, the gulf of Mexico lies to the south, Chambers county and Liberty county form the western line, and Pine Island bayou stretches across the northern end. In total, the county embraces an area of 1,032 square miles. The whole county is low and flat, a great portion of it lying scarcely above high water level. Beaumont, the county seat, has an altitude of only 26 feet above the waters of the gulf. The upper end of the county rises slightly higher than this, but not much, and all the streams of the district are directly affected by the rise and fall of the gulf tides.

The lower half of the county, with the exception of a narrow strip in the vicinity of Sabine pass, is marshy and suitable only for the growth of rice, of which great quantities are annually raised. This same region is also used as extensive cattle ranges, over which the fast diminishing bands of Texas long-horned cattle roam at will. A small portion of the northeastern section of the county is timbered with long-leaf pine (Pinus palustris), cypress along the river, and magnolia. The rest of the county may be considered prairie and more or less marshy.

The climate is mild, almost sub-tropical, and the fig, orange, lemon and banana flourish wherever planted. Corn, cotton and sugar cane also succeed well.

Along the Neches at different places, notably at Grigsby's bluff, and at various points along Taylor's and Salt bayous, mounds of shells occur. These mounds are made up chiefly of the *Gnathodon cuneatus* and lie at considerable distances from the sea, the nearest being at least six miles in a direct line from the lake. The mound at Grigsby's bluff, by far the most extensive of these shell heaps, is about 150 yards long, from 15 to 20 yards wide and from 10 to 15 feet high. This mound is almost wholly made up of the shells of the *Gnathodon cuneatus*, with a few fragments of the common oyster and *Cardium magnum*, all of which are living in the gulf to-day. Mr. Rachford, a local naturalist, tells me that several of these shell mounds contain remains of human workmanship in the shape of broken pottery, arrow points, etc., and that large mounds of a similar character occur on the Sabine river near the town of Orange, in Orange county. At the time of my visits none of these articles were found.

The geology of the county is in many respects *terra incognita*. Nothing but the merest generalization, and that not always correct, has ever been given. The region belongs to the coastal clay regions of the Texas Geological Survey, and Mr. McGee in his "Lafayette Formation" classes it with his Columbia formation and considers this essentially an extension of the Port Hudson clays of Louisiana. This area he describes as follows:

"In central and southwestern Louisiana the Columbia formation is a vast sheet of laminated clays, commonly several hundred feet in thickness, which toward Atchafalaya bayou are frequently blue or bluish gray and charged with carbonate of lime, often segregated in nodular form, while farther westward they become brownish or reddish in color, non-calcareous in composition and arenaceous in texture. Moreover, there is a fairly constant difference between the upper and lower portions of the deposit, the lower strata being coarser and the upper finer, while the uppermost materials are finest of all, particularly within the many shallow interstream basins circumscribed by levee-flanked bayous. Towards and beyond the Sabine these conditions slowly change. In the first place the element of northern rock flour diminishes and the calcareous nodules frequently fail; then the Red river sands diminish and the materials become more tenacious; meantime an element of black mud, such as is carried down by the rivers flowing over the Cretaceous chalks of Texas, appears and the deposit becomes the black tenacious clay characteristic of southeastern Texas."*

The greater portion of the county is of very recent origin and, as already stated, mostly marsh, and the rest belongs to the Port Hudson clays. These clays are, however, very irregular in their appearance and texture, and, although forming the prevailing substructure of the country, frequently give place to very extensive deposits of sand. The element of black mud referred to by Mr. McGee as forming the prevailing characteristic black tenacious clay of southeastern Texas, is nowhere present within the county. The presence of such black mud can hardly be looked for in this region, as none of the rivers directly involved obtain any of their sediment from the Cretaceous areas of the state. The Neches, with its most important tributary, the Angelina, are both confined to the Tertiary areas throughout their whole length, while the Sabine can only be said to enter the Cretaceous in Hunt county, through the interposition of several small creeks forming its headwaters. The lime nodules, although characteristic of the clays, are by no means universal, but occur usually in patches, some of which are very extensive. On Pine Island bayou the Port Hudson clays are seen near the railway crossing at the Sabine & East Texas railway bridge, and still farther down the bayou at John Kerr's ferry. There they are pink and blue clays, the blue predominating. In a deep sewer near the railway station in Beaumont the section shows from two to

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*"Lafayette Formation," *W. J. McGee.* Twelfth Annual Report, U. S. Geol. Survey, pp. 404-405.

three feet of brown sand underlaid by dark blue clay, containing great quantities of small, rounded, limy nodules. The thickness of this clay is unknown, but it shows over ten feet in the sewer. The same clay is also seen in the river bluff about a mile below the main portion of the town, and it underlies a great portion of the prairie south and west of Beaumont. On the coast the same blue clay is recorded as having been found by the Coast Survey in looking for a foundation for a lighthouse, and it also forms a bar across the mouth of the Neches, causing a shoaling of the water from 24 feet in the river to 8 or 10 feet in the lake.

North of Beaumont these clays occur in most of the wells, and at several places are reported to contain shells, chiefly oysters. A well bored at Mr. Fletcher's house in Beaumont shows a section of

		Feet.
1.	Blue clay with thin strata of sand	20
2.	Sand with broken shells	10
3.	Blue clay and sand	125
4.	Sand containing shells	5
5.	Heavy stiff blue clay	60
6.	Blue sand	30
7.	Blue sand and clay, the sand sometimes in beds of 30 feet, to bottom of well	163
	Total	413

A small flow of water was obtained in this well. The water, however, was brackish and unfit for household purposes.

The point selected for the oil and gas well was a slightly elevated mound situated on the prairie about five miles south of Beaumont. This mound is one of several such places occurring throughout the county, and only differs from the others by the presence of several springs locally known as "sour wells." These wells are deserving of notice chiefly on account of the peculiarities exhibited by them. There are five springs or wells in all. These lie along the base of the western side of the mound in small, rounded depressions, totally devoid of vegetation, and while each emits a considerable quantity of hydrogen sulphide the color and taste of the water are different in each well. Four of them are of greenish hue, varying in intensity from light to dark green, and the fifth is of a yellow or straw color. In taste they are all strongly acid, the straw colored one being intensely so. Free sulphuric acid appears to be present, but unfortunately I had no means of verifying this or ascertaining the quantity.

Great quantities of hydrogen sulphide are found at all times, not only issuing from these wells, but at many other places along the sides and even on top of the elevated area.

This condition appears to have been the determining cause for the selection of the place for boring. An additional incentive appears to have been that some fifteen miles to the westward lies Sour lake with its oil or tar wells and mineral springs, and about sixty miles to the eastward, in Louisiana, lie the much talked about Calcasieu sulphur mines, in which both oil and sulphur had been reported to be found as far back as 1871, and the prevailing, although erroneous, impression that great quantities of petroleum occur almost anywhere throughout eastern Texas.

From these statements the company, aided by a local speculator, had deduced the idea that unlimited quantities of oil, natural gas (CH_4) and sulphur were to be found at a depth not exceeding 250 or 300 feet at most.

The boring was carried on by the Chapman hydraulic rotary process, and the specimens of the borings were obtained by passing the material through a series of very fine sieves. While the section may not be absolutely correct, it is as nearly so as this method of boring will admit. The boring after a great many difficulties was carried down 400 feet, and the company, failing to find the deposits they had been led to expect, stopped the work. The section shown from specimens obtained by myself while the work was in progress is as follows:

		Feet.
1.	Gray sand with bluish tint in places	20
2.	Dark gray sand with particles of lignite	7
3.	Blue clayey sand	13
4.	Blue sand	15
5.	Blue sandy clay or mud with iron pyrites A strong flow of hydrogen sulphide came from this bed after the well had remained open all night.	5
6.	Fine blue sand and clay with finely divided iron pyrites disseminated through the bed	10
7.	Blue sand with iron pyrites	5
8.	Fine light blue sand with iron pyrites in fine particles	25

		Feet.
9.	Blue sandy clay	18
10.	Grayish blue sand	12
11.	Grayish blue sandy clay	15
12.	Blue sandy clay	15
13.	Coarse grayish blue sand with iron pyrites	10
14.	Fine grayish blue sand, gray when dry	25
15.	Blue sandy clay with iron pyrites, small flow of sulphur water and small quantity of hydrogen sulphide	5
16.	Gray sand containing great quantities of coarse black siliceous pebbles from ¼ to 1 inch in diameter and some fragments of rotten wood	10
17.	Fine-grained gray sand with small pieces of wood	28
18.	Bluish gray sand to bottom	162
	Total depth	400

No shells of any sort were obtained from the well.

The five feet between 55 and 60 feet (No. 5 of section) contained a considerable quantity of hydrogen sulphide, but besides its being extremely soft no other peculiarity was noted in the large well. It was only after another small hole had been bored down to it that the actual condition of this stratum was ascertained. For some purpose or other a two and one-half inch hole was bored about 15 feet from the south side of the derrick to a depth of 60 feet and a casing inserted. On the completion of this boring a small quantity of gas issued from it for several hours. With the view of seeing whether the end of the casing had passed the gas-bearing sands the tube was raised about ten feet. This caused a heavy volume of gas to flow, which within an hour or two brought up large quantities of a fine, blue, sandy mud in a very liquid condition. This outflow of gas and mud formed a veritable mud geyser, which shot up to a distance of 15 or 20 feet above the mouth of the tube at intervals of from three to five minutes. When not ejecting mud the gas, if ignited, burned with a bluish flame, from 8 to 10 feet in length. The extremely offensive smell from the escaping gas and the almost incessant spray of mud became so disagreeable to the men working around the machinery that it became necessary to plug the small boring. Occasionally, however, during the three months of my stay, when the work was stopped, the plug would be removed and the gas and mud allowed to issue. During the whole of that time there appeared to be no cessation of activity in the flow, as it was always quite active when allowed free vent.

Three hundred feet west of the well and at the base of the mound, in digging a pond to supply water for the pumps, the same liquid, sandy mud was found at a depth of eighteen feet, or about the same level as the stratum in the well. In the bottom of this pond there were many soft spots showing a brown, oleaginous mud, and throughout the digging numerous gas vents were seen, all of which were beautifully lined with thin coatings of sulphur, while several small lumps of sulphur occurred scattered through the clayey sand. Whether these were derived from old gas vents or not, could not be ascertained.

The main peculiarity about this mound is that it rises like an isolated hill of sand from a level sea of clay. It is everywhere surrounded by level (or approximately so) beds of dark blue clay, all more or less calcareous, and some of it extremely so, with thin deposits of sand interstratified here and there and from which good, clear, fresh water is obtainable almost anywhere at depths not exceeding twenty feet. The top of the mound covers an area of probably fifty acres and is slightly porous. Small, irregularly shaped depressions occur in several places, from the bottoms of which considerable quantities of gas are always escaping.

The occurrence of this liquid mud with its attendant gas does not appear to be singular within the coastal country, although none, so far as I know, has previously been recorded from any portion of the Texas area. In the artesian well at New Orleans, bored in 1854, No. 5 of the section is recorded as "a dark semi-fluid clay, nearly destitute of grittiness."* This occurs at a depth of 31 feet, and it also appears from Dr. Hilgard's report that the same liquid mud occurs everywhere beneath that city at depths varying from 37 to 56 feet,† depths which correspond very closely with that in the Beaumont well.

Regarding the origin of this and the several other mounds of similar structure within the county the question may be asked. Are they gigantic mudlumps having a similar formation and origin as those found in the delta of the Mississippi? In many respects these mounds resemble the mudlumps described by Hilgard,* and their existence at the present time may be due to the sandy nature of the materials forming their body and the rapid growth of the marsh to the south, protecting them from the active erosion of the sea. The gas associated with the Mississippi mudlumps appears to be carburetted hydrogen, but in Jefferson county the gas is purely hydrogen sulphide. No salt wells occur in the vicinity of these mounds, although they occur at various places south and east of Beaumont.

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*See section in Physics and Hydraulics of the Miss. River, 1861, p. 101.

†Geology of the Delta and Mudlumps of the Mississippi River, Am. Jour. Sci., III, vol. I, pp. 244-246, 356-368, April and May, 1871.

BRITISH DRIFT THEORIES.

By Warren Upham, Somerville, Mass.

The attention and general approval which have been accorded by English and Scottish reviewers to the recent book by Sir Henry H. Howorth,† which sets aside the glacial theory, and substitutes for it the debacle theory, earliest thought out and long ago abandoned by geologists, seem surprising to American readers, since a most wonderful and unique but gentle agency of formation of the drift is by these authors discarded in favor of a still more strange and extravagantly violent hypothesis. Among the latest and most important of these British estimates of Sir Henry's work, we note three carefully written long articles, each of 20 pages or more, which have appeared in the Scottish Review for September, 1893, the Edinburgh Review of the same date, and the Quarterly Review for January, 1894. The first of these is by D. Gath Whitley, and the other two are anonymous. It is further to be remarked that the magazines containing these two articles are very venerable, being in each case in the CLXXVIIIth volume. On this question we may perhaps say that they are conservative, but more properly that they seek to revive an old opinion which had its day at the beginning of investigations of the glacial drift, but long ago became entirely obsolete.*

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*Ibid, p. 367.

†Reviewed in the American Geologist, vol. XII, pp. 181–187, Sept., 1893.

Another outcropping of nearly the same ancient opinions is found in the February number of the Nineteenth Century. Prince Kropotkin, who had written in the January number on the present lively interest and discussions concerning the theory of the formation of the drift by land ice, which he accepts and shows to be a full explanation for his own country (Russia), believing, too, that the Ice age was continuous, without definite interglacial epochs, is criticised in the ensuing number by the Duke of Argyll, who takes this occasion to place himself on the side of submergence and floating ice, or even the debacles of Sir Henry Howorth, rather than in alliance with his illustrious countrymen, Prof. James Geikie, the late Dr. James Croll, and Mr. T. F. Jamieson, who are in the first rank of glacialists.

Doubtless one chief element in the current of present thought and studies on this subject, which especially gives countenance and encouragement to this extravagant early doctrine, now revived and again vigorously advocated, is the view recently advanced by the venerable and honored Prof. Joseph Prestwich, who holds the place of Nestor among British geologists, accounting for the formation known as "rubble drift" or "head," which has long been a puzzling problem in southern England, by the hypothesis of somewhat similar violent rushes of water, while the sea is supposed to have been flowing off from the land when it was being rapidly uplifted from a very brief submergence. This view is published in two most valuable articles, the earliest treating of the British rubble drift in pages 263–343, with a map and sections, in the Quarterly Journal of the Geological Society, vol. XLVIII, for

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*See Prof. J. Geikie's "Great Ice Age," chapter III, and Lyell's "Principles of Geology," eleventh ed., 1872, chapter VI. In America the theory of the formation of the boulder-clay or till by icebergs or floes, during a period of submergence, appears to have been first proposed by Peter Dobson, of Vernon, Conn., from his observations of striated boulders found on the surface and at considerable depths in excavations (Am. Jour. Sci., first series, vol. X, Feb. 1826, pp. 217, 218). This was better than the theory of debacles or violent waves of water, as produced by earthquakes, which were thought to carry the drift without the aid of floating ice. The chronologic order of the successive debacle, meteoric, denudation, iceberg, and land ice theories of origin of the drift, and their advocates, are fully set forth by Prof. N. H. Winchell in the Popular Science Monthly, vol. III, pp. 286–289, July, 1873.

1892; and the second describing and explaining the analogous rubble drift in the Mediterranean region of southern Europe and northern Africa, forming pages 903–984 in vol. CLXXXIV, for 1893, of the Philosophical Transactions of the Royal Society of London. Similar conclusions, drawn from less extended investigations, had been published by Prof. Prestwich in 1875 and 1880.

Although the rubble drift in southern England and Wales is ascribed by Prestwich to a marine submergence of 900 or perhaps 1,000 feet, the only fossils found in the formation are those of land shells and land animals, and no shore line nor terrace of marine erosion or beach deposition has been detected, such as would mark the limits or stages in the oncoming or decline of the submergence. Prof. Prestwich thinks that the effects observed indicate simply currents of the sea flowing down from the hillsides while the land was suddenly rising, rather than that the rubble transportation was due to waves of earthquake origin. It is very difficult, however, at least for me, to see how such currents, even with estuarine tidal action, could have produced the observed results, for, the total rise being only about 1,000 feet, it would hardly have more effect than the flow of a powerful river current upon its banks during the few minutes in which the flow would advance 1,000 feet. If the emergence were at the rate of the fall of tides, as one or two feet in an hour, 25 or 50 feet in a day, and the whole amount of 1,000 feet in a month, requiring longer time if subdivided by intervals of rest, it would be quite inadequate to form the rubble drift. But so sudden, and not seismic, uplifting of extensive areas as this supposed by Prestwich for western and southern Europe, and in America by Shaler for the coastal border of New England,* seems to be physically impossible.

It seems to me, on the contrary, far more probable that the true explanation of the origin of the rubble drift is supplied by the second of the previously proposed hypotheses concerning it, which Prestwich states but rejects, namely, "the agency of ice and snow sliding down the hill-slopes, aided by the running off of the water resulting from the melting of the ice and snow."[*] The region lies south of the limits of the ice-sheet and the true glacial drift, but I think that during a geologically short time, coincident with the European glaciation, this western side of the land-areas in the eastern hemisphere was greatly but slowly uplifted to the extent of the "2,000 feet or more" which Prestwich mentions on pages 305 and 329, causing southern England and all the countries bordering the Mediterranean to experience a much more severely frosty and snowy climate than now. This view is harmonious with the epeirogenic theory of the cause of the Ice age, which has been thought out and formulated by Dana, Le Conte, Wright, and the present writer.[†]

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*U. S. Geological Survey, Seventh An. Rep. for 1885-86, pp. 310, 320, 321; Bulletin No. 53, 1889, "The Geology of Nantucket," pp. 44, 45.

Condensed into one paragraph, the epeirogenic explanation of the Ice age sees in the fjords and submarine continuations of river valleys a proof that the drift-bearing areas immediately before the accumulation of the ice-sheets had been gradually elevated thousands of feet, until finally the cool plateau climate at the culmination of the uplift brought on the Glacial period; in the low condition of the lands when the drift was left by the retreat of the ice, it sees that these areas had sunk beneath their ice weight, until mostly they stood somewhat below their present level; and in the postglacial uplift of the marine Champlain deposits, overlying coastal portions of the glacial drift, it sees an effort of the earth to regain the state of isostasy, or flotation of the crust on the heavier mobile interior which is capable of flow whether it be solid or molten.

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[*] This is the view held by Prof. James Geikie, "Prehistoric Europe," 1881, pp. 224–227; and earliest by Mr. R. A. C. Godwin-Austen, who thought that southern England was then elevated sufficiently to bring all its higher portions into altitudes having excessive cold, Quart. Jour. Geol. Soc., vol. VI, 1850, p. 94, and vol. VII, 1851, p. 121. Compare the discussion by A. C. Ramsay and James Geikie concerning the origin of the frost-riven limestone-agglomerates of Gibraltar, where they conjecture that 6,000 or 7,000 feet would be the amount of its uplift requisite to cause the severe Pleistocene climate (Quart. Jour. Geol. Soc., vol. XXXIV, 1878, p. 505–541); also, see J. Y. Buchanan's description of the submarine cañon of the Congo, extending to a depth of 6,000 feet beneath the sea (Scottish Geographical Magazine, vol. III, 1887, pp. 217-238; Proc. A. A. A. S., vol. XLI, for 1892, pp. 171–173; and Am. Jour. of Science, III, vol. XLVI, pp. 116, 117, Aug., 1893).

[†] James D. Dana, Presidential Address, Proc. A. A. A. S., vol. IX, for 1855, pp. 23–29; Trans. Conn. Acad. of Arts and Sciences, vol. II, 1870; many papers in the American Journal of Science; and the several editions of his Manual of Geology.

Joseph Le Conte, Bulletin, Geol. Soc. of America, vol. II, 1891, pp. 323–330; Elements of Geology, third edition, 1891, p. 589.

G. Frederick Wright, The Ice Age in North America, 1889, chapter XIX; Man and the Glacial Period, 1892, chapter IX; Amer. Jour. of Science, third series, vol. XLVII, pp. 184–187, March, 1894.

Warren Upham, Appendix of The Ice Age in North America, pp. 573-595; Am. Jour. of Science, vol. XLVI, pp. 114–121, Aug., 1893; Bulletin, Geol. Soc. of America, vol. V, 1894, pp. 87–100.

EDITORIAL COMMENT.

THE COLUMBIAN EXPOSITION.

The Harvard University Geological Exhibit.

In gathering together materials for an exhibit, the intention of the geological department was to show as far as possible the methods of teaching, the working resources of the department, and student products. A more showy exhibit might have been made had the exhibition collections and libraries been resorted to, but the educational value would have been lost. It was evident that from the nature of the case, as well as the small space available, only a qualitative idea of geological teaching could be given, so the observer must gain his idea of the whole from suggestive samples. Finally the samples chosen were fair representatives of resources, selected as they could be spared, and at the same time fully illustrating some points in the teaching of geology. The care taken in the selection and arrangement of materials and in the explanation of the exhibit gained for it an award of merit.

Of the elementary courses the one taken by the greatest number of students is a lecture course with illustrations by lantern slides, photographs and specimens. A set of photographs showing wave action was exhibited as the sample of illustration. For students having a further interest in geology there is an elementary laboratory and field course whose scheme of lectures, laboratory work and excursions was set forth in detail by means of a large notice. The kind of materials used was shown by plaster models, maps, diagrams, photographs and rock specimens. Geological maps and sections made by students in the class were shown as products.

The intermediate geological course, which consists of lectures, field work and reports, though employing lantern views, models, maps, sections and photographs in teaching, was illustrated only by products,—a list of thesis subjects and references, and some geological maps of small local areas, by students. The region about Cambridge is divided into areas of a mile square and each year a student is assigned to an area; the various geologic features are indicated by as many colors as are necessary. The accuracy of the work is tested by comparison with a manuscript map prepared by the instructor and by special excursions to the area. The variety of features found in this region appears in the note given below describing the photographs exhibited. Library research is carried on by the students following the thesis list and references, and the results of such investigation are given orally to the class or written in thesis form.

The next step in geological training is a field course, the advanced summer school. A map including southern New England and a large part of New York state showed the districts visited by the school; and the details of the Catskill and Meriden regions were shown upon maps of a larger scale. Specimens collected at the localities studied and systematically arranged showed the lithological and paleontological evidence by which the structural geology is determined. As now arranged, this summer work begins at Utica, N. Y., with the horizontal Palæozoic formations. Abundant fossils aid in identifying horizons, and by a series of sections the sequence of formations is determined. A considerable part of the same series of strata is identified near Catskill, N. Y., but is divided into two unconformable series, folded and faulted. The folds are of the Appalachian type, on a small scale, and display well the relation of surface form to structure. About Meriden the Triassic sandstones of the Connecticut valley are studied. The evidences for the intrusive and extrusive origin of the trap sheets are carefully observed. By a series of excursions the faulted structure of the region is demonstrated, and by means of maps and sections estimates of the amount of dislocation are obtained. Student note books represented products of the course.

The final course in general geology is one of research under the direction of the instructors of the department. Products only were exhibited, consisting of geological maps and sections, photographs, models, ripple marks experimentally made, and theses. The natural advantages of Cambridge as a geological center were shown by a map of the vicinity of Boston, with numbered localities explained by a descriptive list, and illustrated by photographs. Among the subjects shown were sea-shore features, such as cliffs in hard rock and in glacial deposits, beaches of different kinds, sea-shore chasms, wave-built spit and wave-cut beach above the present shore level, and tidal marshes with meandering streams; noteworthy among the glacial subjects were a cross section of an esker, cuttings showing contorted gravels and faulted sands, and roche moutonée forms; of the bedded rock views those showing numerous complex relations between sedimentary and metamorphic rocks and igneous intrusives of different kinds, as well as between the intrusives themselves, were of greatest interest, for in one view could be seen granite including diorite breccia cut by a diabase dike which has been much faulted.

The natural adjuncts of the general geological course were represented in a similar manner. To illustrate the elementary course in physical geography were shown selected maps of land and sea areas and sets of paper models with explanatory cards. It was noteworthy that some of the foreign maps here shown as parts of the laboratory equipment were also shown among the foreign exhibits as samples of fine work. One set of models selected showed the development of river drainage. The first conditions represented were of a land mass well elevated, the main streams flowing along valleys having narrow bottoms and with rather steep sides; the side streams, beginning in but few branches on the upland, had cut no considerable valleys; the stage of development is that of youth. A second model indicated the result of further growth headwards of the various streams. The main stream valleys have been filled with sediments, and the streams have begun to meander on their floodplains; the side streams have difficulty in reaching the main stream, some wander considerable distances down the floodplain before getting into the master stream, some have been lakes, and into the lakes are growing deltas fed by the little branches. The whole is typical of adolescence. The stage of maturity was manifest in the next model; the streams have the greatest development possible, no part of the land mass is undrained and the drainage flows off quickly without hindrance on floodplains or delay in lakes. A fourth model brought out the effect of a glacial accident upon such a land mass as the last. The perfect drainage has been entirely disarranged; streams in old valleys struggle with the glacial detritus, some are unable to follow former courses and from lakes escape in new directions. Lakes everywhere abound, on main streams, on side streams, and among the hills; some have no visible outlet.

Meteorology, a subdivision of physical geography, was noted by specimen weather maps, foreign and American charts of temperature and rainfall, diagrams of vertical temperature gradients, and photographs of clouds, storm surf, and lightning flashes. Photographs of clouds loaned by this department appeared in the exhibit of the U. S. Weather Bureau. A product of advanced student work in meteorology was a chart of isonomalous temperatures. The diagrams of vertical temperature gradients were perhaps more characteristic than the other materials of the method followed in the elementary course. One of them showed the strong departure of the vertical temperature gradient from the adiabatic gradient in winter anticyclones, thus explaining the marked inversions of temperature that accompany these weather areas; the other exhibited the close agreement of the two kinds of temperature gradients in foehn or chinook winds; the difference between the two diagrams being referred to the difference in the rate of descent of air masses in the anticyclone and the foehn.

The opportunities and methods of studying the petrographical side of geology were made evident by samples of rocks with accompanying thin sections, selected from the various large collections of both foreign and American materials available for study; sample models suggested the study of optical mineralogy; photographs of optical instruments, machines, workshops, and laboratories, completed the exhibit of resources. A photograph showing a large electric microscope together with its projection on the screen of a rock slide, manifested an important method of illustrating lectures, though, of course, specimens, maps and photographs are also used. The products of petrographic work consisted of rock sections with microphotographs of rock sections in both black and colored prints.

Two of the courses in paleontology were represented. The first is a combination lecture and laboratory course in which the subject is treated from its biological side; the specimens presented illustrated the biological method of teaching, recent forms being used together with fossils to demonstrate development. Cut and polished specimens, thin sections and plaster casts indicated the variety of materials used in the laboratory. The second course is chiefly a laboratory course, consisting of the study of the characteristic fossil forms and lithologic appearance of the numerous geological horizons. Materials from a few horizons were exhibited. Photographs of the laboratory taken with students at work and the instructor in attendance were typical of a busy department.

Some colored sections and diagrams of veins and ore deposits evidenced the quality of illustration used in connection with the lecture courses upon economic geology.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Flora of the Outlying Carboniferous Basins of Southwestern Missouri. By David White. U. S. Geol. Survey, Bulletin No. 98, 1893, 8vo. 139 pp., 5 pl.

The material forming the basis of this work was mainly obtained by W. P. Jenney, of the U. S. Geological Survey, in 1889 while investigating the zinc and lead products of Jasper and Lawrence counties in southwestern Missouri. The fossil-bearing shales are said to occur in lenticular masses, which lie in eroded depressions in the limestone "of Warsaw—St. Louis age," and to be the most recent fossiliferous rock within the limits of the lead and zinc region known to have been laid down before the ores were deposited.

The identifiable species, barely thirty in all, distributed chiefly among the *Equisetineæ*, *Felicineæ* and *Lycopodineæ*, the author has taken up one by one and treated in a most exhaustive and scholarly manner. The five well executed plates enhance the value of the work largely, although the descriptions are written with great care. After summarizing the distribution of the species as they occur at various localities and horizons throughout the United States, the conclusion is reached that they belong to a flora somewhat younger than that of Clinton; and "if such be the case, the lead and zinc ores of the region must have been deposited at some period subsequent to the formation of a stage probably about the middle of or in the upper half of the Lower Coal-measures."

The author is led to regret that so little has been done on the trans-Mississippi coal flora, but in case he continues his work in this field both he and science at large may yet rejoice that he found it a *tabula rasa.*

Descripçao de uma fórma nova de Trilobite, Lichas (*Uralichas*) *ribeiroi*, by J. F. N. Delgado. (Commissao dos Trabalhos geolog. de Portugal, 1892, pp. 1-31, pls. 1-6.)

Uralichas ribeiroi is an enormous lichad with a prodigious caudal spine (a very unusual appendage in this group), obtained from the upper beds of the Lower Silurian in the basin of Vallongo, Portugal. The species does not widely differ in structure from *Platymetopus* except in the presence of the pygidial spine. The various parts illustrated show that this gigantic trilobite attained a length of 560 mm. or about 22.5 inches; a size, however, probably equaled if not surpassed by the *Terataspis grandis* Hall, a lichad of the Upper Helderberg faunas.

Note sur un nouveau Eurypterus du Rothliegendes de Bussaco (*Portugal*); by W. de Lima. (Commun. da Commissao dos Trabalhos geolog. Tom ii, Fasc. ii, 1892.)

Eurypterus douvillii, sp. nov., is the only known representative of this genus from faunas so late as the Permian. This species is a small one, characterized by its broad cephalon and thorax, and slender abdomen, as well as by the great prominence and posterior position of the ocelli.

Age of the Newark brownstone. By B. S. Lyman. (Proc. Amer. Phil. Soc., vol. 33, pp. 5–10, 1894.)

From a few imperfect fossil plants, which have been obtained from the Newark, N. J., brown sandstone and which seem to be similar to Carboniferous forms, the author concludes that there is reason to doubt the Mesozoic age of this rock. G.

Report on the Coal Measures of Blount Mountain. By A. M. Gibson. (Geological Survey of Alabama; 8vo., pp. 1–80, 1893.)

This is a report of explorations conducted by the Survey in a practically undeveloped coal region, which lies in Blount, St. Clair and Etowah counties, Alabama. A number of detailed sections are given, which show that coal seams are quite abundant in this region, and it is stated that there are eleven or twelve of these seams that are over three feet in thickness and that furnish coal of good quality. G.

Further observations upon the occurrence of diamonds in meteorites. By O. W. Huntington. (Proc. Amer. Acad. Arts and Sciences, vol. 29, pp. 204–211, with two plates.)

A considerable quantity of the Cañon Diablo meteorite, from Arizona, was dissolved and the diamonds, which occur only in minute grains, were separated; among them were found a few small octahedrons. Some of the material was used in cutting an ordinary diamond and did the work well. From the crystal form, the hardness and the chemical composition there is no reason to consider the diamonds of this meteorite as other than true diamonds. It is suggested that diamonds may have originated in deeply buried masses of iron, as it has been shown by Moissan that carbon can be made to crystallize out of melted wrought iron in the form of diamond, if the iron is allowed to cool under pressure. G.

On the conversion of chlorite into biotite in rock-metamorphism. By Charles Callaway. (Geol. Magazine, III, vol. 10, pp. 535–8, Dec. 1893.)

The author in a former paper (Q. J. G. S., Aug., 1889, p. 475) has contended that the biotite of the gneisses and schists of Malvern was produced out of hornblende through the intermediate form of chlorite. This conclusion seems to have been questioned. He mentions several others,—Lossen, Michel Lévy, Salomon, and Rudermann,—who have described the production of biotite from chlorite, and then proceeds to a theoretical discussion of the question. He attempts to account for the necessary gain, in this change, of silica, iron oxide and potash, and for the loss of magnesia and water. The degradational change of biotite to chlorite is well known, but this reconstructional change of the latter to the former is not so well known, and is of special interest in the study of metamorphism. G.

On the basalts of Kula. By Henry S. Washington. (Amer. Jour. of Science, 3, vol. 47, pp. 114-123, Feb., 1894.)

Near Kula, in Asia Minor, are found a number of volcanic cones from which have come many flows of hornblende basalts in comparatively recent times, but none of these cones are now active. These basalts are structurally divided into normal, hyalopilitic, semi-vitreous and tachylytic. Leucite is for the first time reported from a hornblende basalt. The hornblende shows alteration, due to magmatic action, in three ways, the most important of which is to an aggregate of augite, opacite, and a brown mineral which the author thinks is hypersthene. These basalts are characterized by a large amount of hornblende, and the name *kulaite* is proposed for "a sub-group of the basalts which is characterized by the invariable presence of hornblende as an essential constituent, which also, both in quantity and petrographical importance, surpasses the augite; in other words, to a large extent replaces the latter. We can call such a plagioclase-basalt kulaite, having the further subdivisions of leucite-kulaite, and nepheline-kulaite." G.

On the chemical composition of staurolite, and the regular arrangement of its carbonaceous inclusions. By S. L. Penfield and J. H. Pratt. (Amer. Jour. Science, III, vol. XLVII, pp. 81–89, Feb., 1894.)

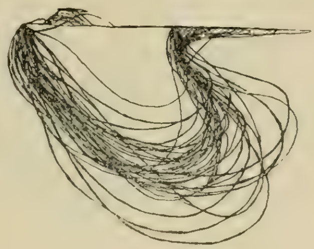
Ten very careful analyses were made of selected staurolite crystals from St. Gothard, Switzerland; Windham, Me.; Libson, N. H.; and Burnsville, N. C. The results agree very closely with each other, and the ratios obtained from the analyses give the formula $HAl_5FeSi_2O_{13}$, which was suggested by Groth. This is the most reliable work done on the chemical composition of staurolite. A number of sections cut across crystals show that the carbonaceous inclusions are arranged in certain planes so that each staurolite prism contains two skeleton or phantom pyramids, outlined by carbonaceous material, whose bases correspond to the basal planes of the staurolite and whose apices join at the center of the crystal, while from the acute and obtuse edges of the pyramids the inclusions extend as films or fins to the vertical edges of the prism. G.

Continuity of the Glacial Period. By G. FREDERICK WRIGHT. Am. Jour. of Science, III, vol. XLVII. pp. 161-187, with sections and five maps; March, 1894. It is proved, as the author thinks, by his observations and those of Mr. Leverett and others, that the erosion of the rock gorges of the Ohio river and its tributaries was preglacial, instead of being interglacial, which last has been their interpretation by Prof. Chamberlin. It is further urged that this removes the necessity for the belief in a long interglacial epoch, and that it appears more in accordance with all the facts known to ascribe the glacial drift to a single and continuous Ice age. On very slender evidence Mr. McGee has estimated that an epoch of warm interglacial climate in northeastern Iowa extended through probably 200,000 and perhaps 2,000,000 years; but the forest bed enclosed between deposits of till, on which his opinion rests, is thought by Prof. Wright to be explainable by short retreats and soon returning advances of the ice-sheet, with a forest at its border, as in the case of the Malaspina glacier in Alaska.

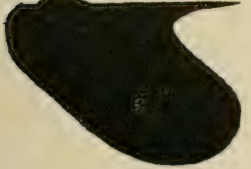
CORRESPONDENCE.

COMPOSITE GENERIC FUNDAMENTA. Some remarks on "Mathematical Biology" in the February number of "Natural Science," and the suggestion made by Bather in his recent work on the "Crinoidea of Gotland," that Galton's method of composite portraiture might be employed to ascertain a specific type from which variations in various degrees could be reckoned, recalled to me some germane experiments in which I was interested some eight years ago, and which indicate that there is even a possibility among narrowly restricted, up-to-date genera, of educing, by a series of comparative measurements and successive overlays, a sort of generic *fundamentum.* I take the liberty of citing and illustrating a single instance of this among the fossils, the case being a simple one and involving the search for the standard in one element of variation only, namely, *outline*; but whatever may be done with a single specific character, in this manner, is equally possible of all the others.

In volume V, pt. I, of the Palæontology of New York are described 57 species of the lamellibranch genus *Leptodesma*, two of which are ascribed to the horizon of the Hamilton group, and 55 to the fauna of the overlying Chemung beds. *Leptodesma* is an aviculoid genus with smooth and convex valves, and the shells upon which these observations are based, are preserved plump and without disturbance of the marginal outline. The genus in some of the higher beds of the Chemung group is enormously prolific, so that the perception and identification of these 55 specific values is a puzzle to which the identification of Jurassic Ammonites or recent Unios is but play. Nevertheless, no more instructive series of variations of a single generic type has ever been described among Palæozoic fossils. The first onset at such a group is certain to lay the student low with acute brain-fag, and leave upon his mind a hazy conviction that all the alleged species are pretty much one and the same thing. The beauty of the series and the persistence of its variations or species dawns upon the mind gradually but invincibly. Having attained this point in the study of the original specimens of these fossils, the attempt was made by the process of superposition to ascertain a standard or radicle outline for the entire generic group. In the making of this composite figure, which is here reproduced, it was, of course, necessary to fix upon two points or one dimension as a base to which all the elements could be reduced or elevated; just as in composite portraiture, the eyes, or some other indices, of all faces in the composite must be coincident. In this case the standard to which all have been made to conform has been the distance between the anterior cardinal extremity and the deepest posterior incurvature of the valve: a purely arbitrary dimension; probably any other would serve as well.



The figure represents superposed outlines of the left valve of 36 of these species of *Leptodesma*. It will be observed that notable differences of outline in the components of this figure are obscured by the coincidence of the lines for a greater or less portion of their length, while the ruling outline or type stands out conspicuously like a coarsely shaded drawing of the valve. Of all the component outlines this interwoven valve approaches nearest to that of *L. rogersi*, as shown in the adjoining figure. It will naturally be understood that *L. rogersi* enters into this combination no more than the other 35 species, nor are there other shells whose outline is so nearly similar to that of *L. rogersi* as to produce a succession of parallel lines, which thus become intensified. The depth and predominance of the *L. rogersi* outline is wholly due to the coincidence of parts of outlines of species which vary greatly in this respect, as witness the four following silhouettes of elements in this composition, shown on page 288.

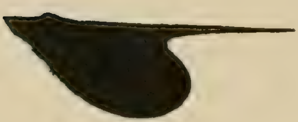
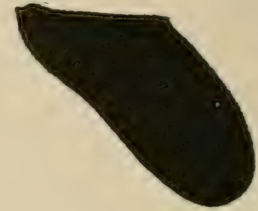
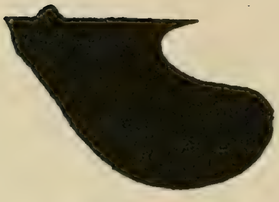
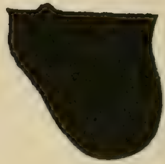


Leptodesma rogersi.

As already remarked, what is here done for the outline of the valves can be done with equal facility for convexity or other specific variations, either by this method of superposition or by the expression of such differences by a series of co-ordinates or mathematical curves.

One interesting fact in regard to the type or *fundamentum* expressed in this composite is that *L. rogersi* (the silhouette of which, here given, is of exaggerated size) is the temporal precursor of the cometary outburst of *Leptodesma* in the Chemung faunas, and is one of the two species occurring in the Hamilton faunas beneath.

I am disposed to believe that whenever this method is practicable it will be found of real usefulness not only to biologists in general, but to the palæontologist in particular, especially in the determination of specific standards or *fundamenta*, as suggested by Bather. Its successful application implies, first of all, abundant data. With that prerequisite provided for, profitable comparisons could be instituted between species of distant faunas, supposed to be identical, or which, though perhaps identical, may be masquerading under different names: and between such species in successive faunas of the same region. As a case in point, the brachiopod species *Athyris* or *Seminula subtilita* Hall would serve: an abundant and remarkably variable shell from the upper Carboniferous. In the lower Carboniferous limestones occurs an allied form, *A. subquadrata*, and it has been confidently asserted that neither species passes into the geological horizon of the other. Yet the two are greatly alike and each appears under many variations of outline and contour. Assuming that the two are alike in internal structure, which I believe to be essentially true, a series of composites might determine whether or not the variations of the two so-called species reduce to similar *fundamenta*, and if they do I should be inclined to regard this as rational evidence of specific identity. Again, the geological value of this method might be tested in such a case as that recently adduced by Prof. Prosser, who argues that an extensive series of rocks in central

and eastern New York, which appear to be permeated with Hamilton fossils, are not of the age of the Hamilton group, but represent a later geological stage, and that the fossils have, in a considerable degree, undergone modifications from their typical expression in the true Hamilton fauna. As the quality of these variations is hardly palpable under ordinary circumstances and has not been satisfactorily expressed in words, it ought to appear in composites based upon sufficient data; and should there prove to be differences in the *fundamenta* of specific variations, from the true Hamilton fauna, and of those from the alleged but contested Hamilton fauna above, the argument from such evidence would be entitled to serious consideration. J. M. CLARKE.

Albany, N. Y., Feb. 22, 1894.

"THE COLUMBIAN EXPOSITION: NOTES ON SOME MESOZOIC AND TERTIARY EXHIBITS." An editorial under the above heading in the March number of the GEOLOGIST, which, though unsigned, was evidently written by Prof. F. W. Cragin, includes notes on several species of Cretaceous fossils exhibited by the U. S. Geological Survey. As these notes contain a number of queries, either expressed or implied, I beg space in which to answer them seriatim, though several of them will be more fully answered in a forthcoming bulletin (No. 106) of the Geological Survey.

In explanation of the fact pointed out by Prof. Cragin that the labels in several instances did not agree with the nomenclature and opinions in his "Contribution to the Invertebrate Palæontology of the Texas Cretaceous," it is only necessary to remind the reader that the collection was on exhibition in Chicago for some weeks before the book was published.

The "two very interesting specimens of Gryphæa, labeled '*Exogyra suborbiculata* Lamarck,'" really belong to *Exogyra*, as that artificial but convenient genus is defined. Unfortunately the specimens exhibited do not show very clearly on casual inspection the distinctly spiral beaks of both valves.

The occurrence of *Radiolites austinensis* in the Eagle Ford shales ought not to be considered remarkable when it is known that there is no distinct faunal break between that formation and the Austin limestone, in which it is well known to occur.

Comparison of the types of *Trapezium micronemum* Meek, *Barbatia coalvillensis* White (both from Coalville, Utah), and other specimens from Utah, together with the Texan fossils that Prof. Cragin has since described as *Arca galliennei* d'Orb. var. *tramitensis*, convinced me that they all belong to one species, and they were placed under the earliest American specific name as *Barbatia micronema*. It is evidently closely related to the European species to which Prof. Cragin refers it, but whether they are really identical can hardly be decided without direct comparison of specimens from both countries. In Utah *Barbatia micronema* occurs with *Glauconia coalvillensis*, *Ostrea soleniscus*, etc., in beds slightly below the horizon of *Buchiceras swallovi* and probably very near the horizon of the Texas Timber Creek beds. The strata containing them in Utah are intimately connected both faunally and stratigraphically with the overlying beds of the Colorado formation, and I have therefore treated them as the base of that formation.

So far as can be determined from a description without illustration, it is quite possible that the fossil doubtfully referred to *Placenticeras placenta* is identical with *P. syrtalis*, var. *cumminsi* Cragin. However that may be, it seems to me to be more closely related to *P. placenta* than to *P. syrtalis*. From the former it seems to differ in its smaller size and slightly less deeply divided suture. If not identical with this well known species from the Montana formation, it may at least be considered its direct ancestor.

Prof. Cragin refers the "Modiola concentrice-costellata Roem.?" to his recently described *Modiola stonewallensis*. This species, like a considerable number of others described as new in the "Contribution to the Invertebrate Paleontology of the Texas Cretaceous," has never been figured,* and it is therefore gratifying to have an example of it identified by the author, who, it is hoped, will take the first opportutity to illustrate all his unfigured species. As to the validity of the name *Modiola stonewallensis*, the figures of *M. concentrice-costellata* given by Roemer are very suggestive of immature examples of this species, and their specific identity is made more probable by the fact that they come from the same horizon.

The Texan species of *Protocardia* probably should not be referred to the European *Cardium hillanum* Sowerby, although Roemer assigned them to that species. The fossils of this group, especially when not well preserved, show so few salient features that it is difficult to define the limits of the species.

In his description of *Astarte (?Stearnsia) acuminata* Prof. Cragin admits that it is probably a synonym of *Stearnsia robinsi* White, and his figure, together with the fact that both came from the same horizon and neighborhood, make their identity almost certain. "The radial marks seen on the beaks of *Astarte acuminata*," as represented in the figure, look like an accidental feature.

The young specimen of *Trigonia emoryi* Conrad is doubtless the young of *T. clavigera* Cragin, and therefore these two names are synonymous. The identification was made by comparison with the type of *T. emoryi*, which so closely resembles the photographic figure of *T. clavigera* that it might have served as the original, excepting that the accidental defects in the two specimens do not quite coincide.

Prof. Cragin is probably right in referring *Arcopagia texana* to *Cyprimeria*, though that reference can hardly be called unquestionable so long as the hinge of the species is entirely unknown. It would be interesting to know why any of the Fredericksburg Cyprimerias have been referred to *C. crassa* Meek, which is a medium sized species from the Upper Cretaceous (Montana formation) of New Mexico.

The queries as to whether certain specimens are types may be answered by saying that types, i. e. figured specimens, were not shown in the Geological Survey exhibit. T. W. Stanton.

Washington, D. C., March 8, 1894.

PERSONAL AND SCIENTIFIC NEWS.

An Arctic expedition for the exploration of the unknown western part of Ellesmere land, in latitude 76° to 78°, is to be led by Mr. Robert Stein of the U. S. Geological Survey, starting from St. John's, Newfoundland, on a whaling steamer in May.

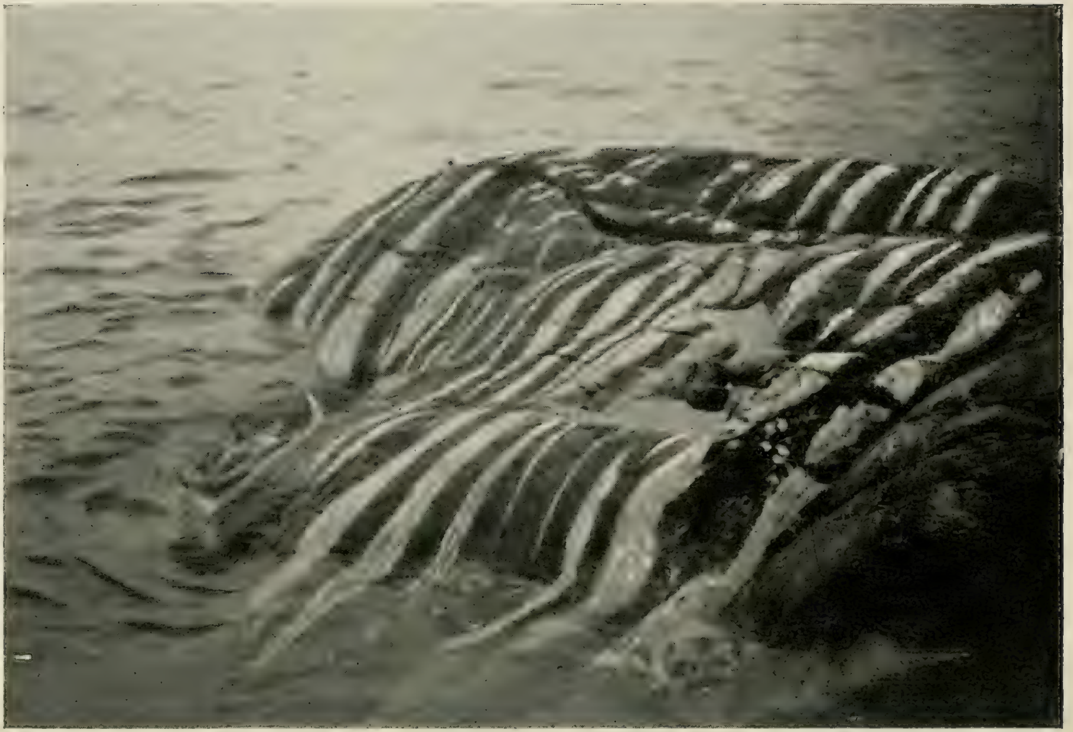
It has been suggested that the Arizona petrified forest, occupying about 10,000 acres in the eastern portion of central Arizona, near Holbrook, on the Atlantic and Pacific railroad, should be set aside as a national park. The ground is strewn with trunks and limbs of petrified trees, some of the logs being six feet in diameter. (*Bulletin*, *Am. Geographical Society*, *Dec. 31*, *1893.*)

The topographic work of the U. S. Geological Survey during 1893 comprised the mapping of about 33,500 square miles. Thirty-three surveying parties were engaged in the field-work, and 134 sheets of the United States topographic map were surveyed. Of these, 118 are on a scale of 1 : 62,500, or very nearly one mile to an inch, each being bounded by sides of a quarter of a degree in latitude and longitude; and the remaining 16 are on the scale of 1 : 125,000, or about two miles to an inch, with half degree sides. In New York, where the state appropriated $24,000 for co-operation with the national survey, 27 sheets have been completed, covering 5,000 square miles. In North Dakota, 11 sheets were surveyed; in South Dakota, 13 sheets, including the completion of the Black Hills area; in Nebraska, 37 sheets; in Kansas, four sheets, finishing the part of the state east of the 100th meridian; in Oklahoma, eleven sheets; in Montana, two sheets on the two mile scale, embracing the region recently set off as a timber reserve, east of the Yellowstone National Park; in Idaho, about 1,000 square miles in the Salmon River mountains; and in California, four sheets about the bay of San Francisco, and three sheets in the neighborhood of Los Angeles. The surveys of Massachusetts, Rhode Island, Connecticut, and New Jersey have been completed and published.

The department of geology at Cornell University has been reorganized, Mr. G. D. Harris being appointed assistant professor of Paleontology, Dr. A. C. Gill assistant professor of mineralogy and petrography, and Mr. R. S. Tarr assistant professor of dynamical geology and physical geography. Mr. Tarr has been connected with the University for the past two years, but the others are new men. Mr. Harris is a graduate of Cornell, and has been connected with the Smithsonian Institution and the geological surveys of Arkansas and Texas, since his graduation in 1886. Dr. Gill graduated from Amherst in 1884, and since then has been five years at Johns Hopkins, Leipzig, and Munich, where, in 1893, he took the degree Ph. D.

Mount Logan, so named by Prof. I. C. Russell in honor of Sir Wm. Logan, the founder of the Geological Survey of Canada, has been found to excel in hight every mountain peak that has been measured in North America. A party under Mr. J. E. McGrath was sent out by Supt. T. C. Mendenhall, of the U. S. Coast and Geodetic Survey, in 1892, to take such measurements of angles and distances as would determine the hight of Mt. St. Elias. In doing this measurements were made on Mt. Logan, twelve miles toward the northeast from Mt. St. Elias. These have recently been computed at Washington and result in transferring the honor from Mt. Orizaba in Mexico to Mt. Logan. There are three peaks having altitudes 19,497 ft., 19,514 ft. and 19,255 feet. Mt. Logan is therefore 1,500 feet higher than Mt. St. Elias and 1,200 feet higher than Orizaba (Am. Geologist, vol. xii, pp. 213-217, Oct., 1893).

The International Congress of Geologists, sixth session, to convene at Zurich 29th of August, will continue to Sept. 2d, having simultaneous sectional meetings and daily general sessions. The second circular of the arranging committee, issued in February, gives the general program and the details of the proposed excursions, the latter being intended to be, evidently, the chief feature of the meeting. Five excursions on foot will take place before the meeting at Zurich and four after it, each under a competent guide, the cost of which varies from ten to fifty dollars. The conductors of these excursions will be Dr. H. Schardt, Dr. Aug. Jaccard, M. Louis Rollier, Dr. C. Schmidt, Dr. Mühlberg, Dr. Alb. Heim and Dr. A. Baltzer. These are intended for those who are hardy enough to endure the labor and hardship of actual travel and exploration, with hard beds and frugal diet. Two longer excursions in the Alps are arranged, one before and one after the session, each occupying thirteen days, the former costing sixty dollars and the latter eighty. These are under the direction of Profs. Renevier and Golliez, of Lausanne, and the travel will be principally by railroad, by steamboat and by stage, occasionally on horse or afoot for short trips aside. The excursions which take place before the meeting will start from different cities in the western or northern part of Switzerland and will converge at Zurich. Those which occur after the session will radiate from Zurich through the Alps and unite finally at Lugano, where the close of the Congress will take place. These excursions will enable the participants to visit the principal classical regions of Swiss geology. The cost of membership in the Congress is fixed at five dollars, the payment of which is the only condition. This sum should be sent to the treasurer, M. Casp. Escher-Hess, Bahnhofstrasse, Zurich.



Multiple Diabase Dyke on an Island at the Mouth of White Gravel River, Lake Superior.

THE
AMERICAN GEOLOGIST

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A MULTIPLE DIABASE DYKE.

By Andrew C. Lawson, Berkeley, Cal.

(Plate VII.)

On a small island opposite the mouth of White Gravel river on the northeast coast of lake Superior there are displayed certain phenomena of a somewhat unique character. The island is not more than about 200 yards in length and is perhaps 100 yards wide. It is composed of common Laurentian granite of a reddish color. The constituent minerals are red and white feldspars, both orthoclase and plagioclase, quartz in abundance, biotite more or less chloritized, hornblende and a little epidote. The rock is of medium texture and has the usual granular structure. There are occasional large phenocrysts of orthoclase, attaining a diameter of half an inch. The rock is entirely devoid of any trace of foliation.

The island is traversed by three diabase dykes. These are part of a great system of similar dykes which traverse the region. The dominant dyke of the three has a strike about S. S. E., or parallel to the general trend of the coast. It fills a clean cut fissure in the granite about 75 feet wide, with vertical, straight parallel walls. This dyke has in a large measure conditioned the topography of the island. The dyke has disintegrated more rapidly than the granite, so that a longitudinal trench has been formed, dividing the island into two parallel hummocky ridges. At each end of the dyke is a cove, forming a sharp indentation in the shore contour. The island has an elevation above the lake of 50 or 60 feet. Its longitudinal profiles are thus those of the hummock, while the transverse sections show a combination of the hummock and negative dyke profiles. The general form of the island is indicated in the accompanying diagram, fig. 1. The other two dykes of the island are confined to the more easterly, or lesser, of the two portions into which it is thus divided by the dominant dyke. The larger dyke is near the S. E. point of the island and is remarkable only for the irregular character of the containing fissure walls. In this respect it differs from the great majority of the diabase dykes of the region, since these as a rule are contained in remarkably straight fissures. The average width of this dyke is perhaps fifty feet. Its strike is S. S. W., so that its projection beneath the waters of the lake would intersect that of the dominant dyke of the island. About fifty feet from the margin of this dyke and occupying a jutting point on the S. E. extremity of the island is our third dyke—the *multiple dyke*, to which this note has especial reference.

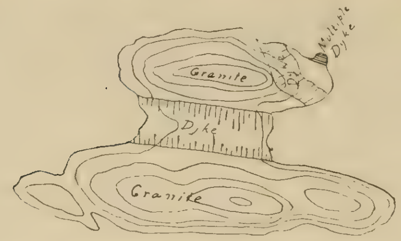

FIG. 1.—*Island at the mouth of White Gravel river, lake Superior.*

The rock surface upon which the phenomena to be described were observed is at the water's edge. Its area is only about 50 x20 feet, and it passes beneath the surface of the lake on three sides. The waves break over the entire area so that it is perfectly clean and bare. The surface is also smooth and polished by glacial action. *This surface is formed of the edges of over fifty thin sheets of granite and diabase in alternating sequence.* These sheets are in vertical attitude. The diabase sheets are dykes cutting the granite. The evidence on this point is absolutely conclusive. Although none of the diabase sheets exceed 6½ inches in thickness and many are not over 3 inches thick, yet there is a very apparent differentiation in the texture of the sheets from their middle portions towards their containing walls. In the middle portions the crystalline texture of the rock is readily observable. At the margins it is a dense aphanite. The diabase sheets were in several instances observed to cut obliquely across the granite sheets so as to anastomose; and little apophyses of the diabase in some cases branch out from the main sheet and die out in the granite. These facts, taken together with the petrographic identity of the diabase with that of the larger neighboring dykes, establishes the intrusive character of the sheets. A section across the edges of these alternating vertical sheets of granite and diabase was carefully measured. The section selected is a representative one, but neighboring sections would be slightly different in detail, as the sheets are not uniformly thick along their strike and, as stated, the diabase sometimes cuts across the granite sheet obliquely. The results of this measurement are as follows, in which the thickness is given in inches, d=diabase, g=granite: D$1\frac{3}{4}$, g4, d4, g$\frac{1}{2}$. d$2\frac{1}{2}$. g$5\frac{1}{2}$. d$4\frac{1}{2}$, d3. g2, d1. g$1\frac{1}{2}$, d6, g2, d3, g7, d$2\frac{1}{2}$. g$4\frac{1}{2}$, d3. g1,d3, g3, d5, g2, d$3\frac{1}{4}$. g$4\frac{1}{4}$. d2, g$2\frac{1}{4}$. d$3\frac{1}{4}$. g$1\frac{3}{4}$. d3. g2. d$6\frac{1}{4}$. g$\frac{1}{2}$. d$4\frac{1}{2}$, g2, d1, g$2\frac{1}{2}$, d1. g$\frac{1}{2}$, d1, g$\frac{1}{4}$, d$1\frac{1}{4}$, g$2\frac{1}{2}$. d5. g$1\frac{1}{2}$. d4, g$4\frac{1}{2}$. d5. g8, d6, g3, d5, g5, d2.

We have thus in a breadth of about 14 feet no less than 28 vertically intrusive sheets of diabase, ranging in thickness from 1 inch to $6\frac{1}{2}$ inches, separated by 27 sheets of granite ranging in thickness from $\frac{1}{4}$ inch to 8 inches. There can be no reasonable doubt that these diabase sheets represent but one invasion of magma and that they are essentially but one dyke, although split up into so many parallel sheets. Such dykes may conveniently be called *multiple dykes*. The extent of the dyke is not known. Its strike is about S. S. E. Its exposure is limited to the rock surface shown in the accompanying photograph (Plate VII). The striping of the surface, due to the alternation of light and dark colored bands of rock, is fairly well brought out in the illustration. The banding is, however, even more uniform than appears in the photograph, seeming irregularities being introduced by pools of water, clefts, shadows, etc.

The interesting feature of the occurrence is the splitting of the granite into so many thin vertical sheets. The granite is seemingly homogeneous. There is no differentiation of structure or of mineral composition,—no trace of foliation. The splitting in parallel sheets would therefore seem to be due to no intrinsic structural feature of the rock itself, but to have been determined by the nature of the forces directed against it from without. There is no evidence of brecciation or of shearing; and it appears improbable that the parallel partings are jointages or faults, since such features are not observable elsewhere in the vicinity. We must therefore suppose that the splitting of the granite into thin sheets was due directly to the invasion of the diabase magma. It would follow from this that the parting planes, having once been established by sudden changes of temperature, or otherwise, the separation of the granite sheets must have been effected by the pressure of the invading magma. The occasional intersection of the granite sheets by the diabase shows that the magma invaded the different parallel fissures at the same time, and that the process of fissuring and filling by magma was not successive but simultaneous. This occurrence has more than a local and special interest. The relations of the intrusive rock to the mass invaded are remarkably similar to those which obtain between the intrusive Laurentian granite and the earlier rocks of the Ontarian system. Geologists familiar with the Archæan on the north side of lake Superior will be impressed by the resemblance of the photographic illustration to many contacts between the Laurentian gneisses and granites and the schistose rocks which they invade. Yet when the writer first described the evidence of the irruptive nature of the Laurentian of the region, the interpretation which he placed upon the parallel interbanding of schist and granite was ridiculed. It was declared impossible that an irruptive contact could assume the characters described, and the interbanding was held to be due not to the invasion of the schistose rock by the granite magma, but to original sedimentation in accordance with the views of the old metamorphic extremists. In the case of the irruptive contacts of the Archæan the injection of the granite magma in parallel sheets within the schists is not so surprising as is the case here recorded. The rocks of the Ontarian system were schistose prior to their invasion by the Laurentian granites, and the parallel planes along which injection took place were already established as planes of fission by the cleavage of the schists. In the present case there were no pre-existent planes of fission in the rock invaded by the irruptive magma. The occurrence is, therefore, interesting as establishing independently of the Archæan contacts the fact that an irruptive magma may invade the country rock in thin parallel sheets alternating with thin sheets of the rock invaded.

GEOLOGICAL NOTES ON THE SIERRA NEVADA.

By H. W. TURNER, Washington, D. C.

[Concluded from page 249.]

PART II.

THE IGNEOUS ROCKS.

The classification adopted below is practically that of Rosenbusch. It is now generally conceded, and I think by Rosenbusch himself, that the classification of igneous rocks on the basis of time is not an altogether scientific one. The rocks called porphyrites are in fact the product of ancient volcanoes and correspond in the main to modern andesites. Some of the rocks classed as diabase do not appear to differ in structure or in original composition from modern dolerites and augite-andesites. The science of petrography is now in a transition stage and the classification here adopted will doubtless not obtain a few years later. In the Sierra Nevada, however, the time classification is very useful. All, or nearly all, of the rocks classed as intrusive are Jura-Trias in age or older. During the Cretaceous period the igneous forces in this district seem to have been quiescent, and do not appear to have been very active again till in Neocene (Miocene and Pliocene) time.

The pre-Cretaceous volcanic rocks are all of them altered, usually highly so. They have been subjected to pressure, rendered in places thoroughly schistose, and folded in with pre-Cretaceous sediments. Nearly every hard specimen of these ancient volcanic rocks will be found on microscopic examination to contain epidote, uralite, or chlorite or other secondary products. They also differ from the Tertiary volcanic rocks in containing numerous gold quartz veins and other metalliferous deposits.

The Tertiary volcanic rocks on the other hand lie with a marked unconformity in nearly horizontal beds or sheets on this older folded series. They are also usually unaltered, and almost never contain metalliferous deposits.

The igneous rocks may be classified as intrusive and effusive, but some of the fragmental diabases and porphyrites that are included under intrusives were undoubtedly surface rocks.

INTRUSIVE.

Amphibolite.	Basic series.
Diabase and porphyrite.	
Hornblende-porphyrite.*	
Gabbro and norite.	
Peridotite and pyroxenite.	
Diorite.	
Granodiorite.	Acid series.
Granite-porphyry.	
Biotite-hornblende-granite.	
Quartz-porphyrite.	
Quartz-porphyry.	

EFFUSIVE.

Rhyolite.	Acid series.
Hornblende-mica-andesite.	
Hornblende-pyroxene-andesite.	
Pyroxene-andesite.	
Older basalt.	Basic series.
Dolerite.	
Other late basalts.	

INTRUSIVE IGNEOUS ROCKS.

AMPHIBOLITE.

The rocks here designated as amphibolite appear all of them to have been derived by metamorphism from igneous rocks. The amphibolites may be classified under three headings: massive amphibolite, amphibolite-schist and amphibole-talc rocks.

Massive amphibolites. Under this head are placed certain granular amphibolites which are known in certain cases to have resulted from the alteration of pyroxenites. No. 240 Amador county and No. 76 Calaveras county are examples.

Amphibolite-schist. The majority of the green schists so abundant in the gold belt are amphibolites, derived as has been shown by the microscope and by field observations, very largely from rocks of the diabase series by dynamometamorphism. The augite of the original diabase may frequently be seen altering into fibrous green hornblende. There is usually in these schists secondary feldspar and quartz, with a good deal of epidote in small grains and sometimes zoisite. These rocks resemble to a marked extent the greenstone schists of Michigan, so admirably described by professor G. H. Williams.* Large areas of amphibolite-schist are shown on the Sacramento, Placerville and Jackson atlas sheets.

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*Some of the porphyrites contain over 60% of silica and therefore belong to the acid series.

Copper. Copper is found in a belt of amphibolite-schist that lies just west of the Bear mountains in Calaveras county, and in the extension of this belt to the northwest into Eldorado county are frequent deposits of copper and iron sulphurets, which have been the source of a considerable copper industry. The ore is said at Copperopolis and at Campo Seco to carry several dollars in gold to the ton.

Amphibole-talc rocks. Rocks of this series occur as narrow streaks in the Paleozoic schists. They have been studied by the writer chiefly in the area of the Jackson sheet, where they appear to occur only in the Calaveras formation, chiefly in narrow streaks evidently representing basic dikes, for in places they contain cores of pyroxene altering to amphibole. This is usually colorless in thin sections and is probably tremolite, but some of the amphibole corresponds more nearly to actinolite. Portions of the dikes are now altered to talc. Sometimes serpentine is associated with the amphibole and talc. In a dike three-quarters of a mile northeast of Oleta (No. 348 Amador county) the pyroxene is plainly altering to serpentine. The largest body of talc rock noted lies two and a half miles northeast of Angel's, in Calaveras county. In this case the area is rounded in shape and about one-third of a mile in diameter.

DIABASE AND PORPHYRITE.

Rocks of the diabase series are very abundant in the Sierra Nevada. They occur as a rule associated with the auriferous slate series and in minor amount associated with granite. Much of the material classed as diabase has been shown, on careful examination, to be fragmental and may be designated diabase-tuff, as the term is used by Rosenbusch.

Some such areas were undoubtedly formed by eruptions which occurred at the time the sedimentary rocks now enclosing the tuff were being deposited; but many of the fragmental diabase areas, or areas which are in part fragmental, that separate the slate belts into wedge-shaped portions, appear to have been intruded sheets or dikes. Such is the Bear mountain area that begins at the south end of the Jackson sheet and extends thence across Calaveras and Amador counties into Eldorado county, a distance of about fifty miles.

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*Bull. U. S. Geol. Survey, No. 62.

This dike or intruded sheet (?) separates for this entire distance, so far as known, the Calaveras and the Mariposa formations, and might be considered as a dike at their contact. At various points, particularly about Golden Gate hill, the diabase of this area extends in long dike-like tongues into the slates of both the Calaveras and the Mariposa formations. An inspection of the geological map of the area (Jackson atlas sheet) seems to leave no doubt that these intrusions cut across the sedimentary strata in places.

No careful study has yet been made of these diabase areas. The dike-like tongues noted above may prove in all cases to be massive diabase or augite-porphyrite, and the fragmental portions of these areas may prove to be interbedded.

There are also large areas in which the material is unquestionably massive, as the area southwest of Latrobe, on the Placerville sheet, portions of which form an augite-porphyrite. In other portions of this area there are scarcely any bisilicates in the rock. No. 510 Eldorado is a sample of such a rock. This contains 68% of silica.

In the northeastern part of the Downieville sheet, in Plumas county, is a very extensive area of diabase. It forms a large part of the western slope of the Grizzly mountains. The same area, apparently uninterrupted, though in places covered by Pleistocene deposits, extends south to Mount Elwell, Gold lake and beyond, having in places a width of six miles. A good deal of this material is breccia, and most of it is more or less roughly schistose, portions of it being converted into a thoroughly schistose amphibolite by pressure. A very pretty example of this dynamometamorphism may be seen just east of Long lake. Here a narrow strip of the diabase has, by pressure and movement, been converted into an amphibolite-chlorite schist (No. 110 Plumas county); and that this strip of schist is an integral part of the diabase and not included in the diabase, is very evident, the rocks having been cleaned off most beautifully by the glacier that formerly covered the area. Even better evidence of the dynamic origin of some of the amphibolite-schist may be seen in the vicinity of Wade's lake, in Plumas county. On the slope to the south of the lake and at other points about the lake there are numerous diabase dikes in the white quartz-porphyry-schist. Some of these dikes are fifteen feet through; others are smaller. In places the dikes have assumed a schistose structure coincident in direction with the schistosity of the enclosing quartz-porphyry-schist, but bearing no relation to the course of the dikes.

HORNBLENDE-PORPHYRITE.

Hornblende-porphyrite occurs abundantly in the southern part of Eldorado county, and to a limited extent in Amador county as fragmental areas and dikes in the western belt of the Calaveras formation (see Placerville atlas sheet). Big Sugar Loaf, in Eldorado county, is a *massif* of hornblende-porphyrite. As may be noted in the text of the Placerville atlas sheet, the hornblende-porphyrite in Eldorado county grades over into rocks of the diabase series. It is probable that these hornblende-porphyrites are of the age of the enclosing slates, that is, Carboniferous. Some of these porphyrites were surface lavas, corresponding to the Tertiary hornblende-andesites. In a thin section from the hornblende-porphyrite area one mile west of Logtown in Eldorado county the devitrified glass shows flow structure very plainly.

In Plumas county on the ridge south of the middle fork of the Feather river dikes of hornblende-porphyrite cut the serpentine. A dike of the same rock cuts the diabase one mile northwest of Gold lake.

It is noted under diorite that there are dikes of a rock allied to camptonite which cut the granite, the schists and the quartz-porphyrite, and in which there are developed poryhyritic hornblendes. These rocks are sometimes designated hornblende-porphyrite, but they may be observed to pass over into undoubted diorites of the camptonite series.

Hornblende-mica-porphyrite. At Indian valley in Sierra county is a small biotite-granite area, and in the surrounding mica and greenstone schists and clay slates, are very abundant dikes of hornblende-mica-porphyrite. At first glance these would seem to be offshoots of the granite mass, but at the east end of the valley on the north side of the Yuba river are several of these dikes from three inches to five feet in width cutting the granite. While, therefore, the dikes may have originated from the same igneous reservoir as the granite, it would appear that they are later in age.

On the south bank of the Yuba river west of Indian valley a dark fine-grained dike six inches wide was noted cutting a dike of hornblende-mica-porphyrite. A microscopic examination shows this fine-grained dike to be a diorite of the camptonite series.

GABBRO AND NORITE.

Rocks of the gabbro series occur not infrequently in the Sierra Nevada, but seldom in large areas. In general they seem genetically related to the granite series on the one hand, and to the peridotite-pyroxenite series on the other.

A mica-gabbro forms a considerable hill, more than a mile in greatest diameter, in Amador county, about two miles west of Plymouth. At other points gabbro occurs associated with serpentine dikes.

The area of gabbro about Whitmore's, in the northeast corner of the Jackson sheet, is a very variable one. While the larger part of the area is a gabbro, portions contain olivine, forming an olivine-gabbro: other portions contain only pyroxene, forming pyroxenite, some of which is entirely altered to hornblende, forming a massive amphibolite: brown mica occurs locally, forming a mica-gabbro; at one point a specimen contains primary quartz, brown mica, plagioclase and pyroxene, with secondary hornblende, forming kersantite; and on the south slope of Mount Crossman is a mass of rock composed chiefly of primary brown hornblende that seemed to be genetically a part of the gabbro area.

In Plumas county gabbro forms the east slope of Eureka peak below the 6,800 foot contour. It there may be seen in sharp contact with the quartz-porphyry that forms the crest of the peak, and as fragments of the gabbro are enclosed in the quartz-porphyry, it would appear that the gabbro is here the older rock.

The area lying four miles southwest of Grizzly peak in Plumas county is in part a typical gabbro (No. 341 Plumas county) of plagioclase and diallage, and in part is composed of hypersthene and plagioclase forming a norite. At one point in the area are developed large black hornblende crystals, some of them more than an inch long. There are also curious concretionary structures in the norite (No. 343 Plumas county). These concretions consist of a central portion that appears to be largely the same as the general mass of the norite, that is, hypersthene and plagioclase, surrounded in the particular one examined by three or more concentric layers, which in thin section are seen to be composed of olivine and magnetite, with intervening layers of plagioclase.

PERIDOTITE AND PYROXENITE.

Fresh peridotite has been found, so far as known to the writer, at very few points in the areas studied, it having, as a rule, been altered to serpentine. Still, traces of the original olivine, together with pyroxene, have been found in many of the serpentine areas, and at a number of points beautifully fresh pyroxenite.

The largest single dike of serpentine, which is known to have been originally a peridotite or pyroxenite, occurs in the northern end of the range in Sierra and Plumas counties. It follows very closely the strike of the strata and when they bend very perceptibly to the northwest, as is the case from Clermont hill in Plumas county to Meadow valley and beyond, this dike likewise has the same northwesterly course. The serpentine at Red hill in Plumas county to the north of the fortieth parallel is a part of this dike, which extends south from that point at least fifty miles. The serpentine of Goodyear's bar in Sierra county belongs to the same area. This dike-like serpentine area has a width where it is crossed by the middle fork of the Feather river of more than three miles. Associated with the serpentine are large amounts of amphibolite-schist. This is especially abundant to the south of Onion valley in Plumas county. It seems at some points to replace the serpentine, which occurs sometimes to the east and sometimes to the west of the amphibolite, and sometimes, as two miles south of Onion valley, the serpentine is bordered on both sides by a belt of amphibolite-schist. To the north of the middle fork of the Feather river the amphibolite-schist is coarsely fibrous and forms a very definite belt one-half mile or more wide to the east of the broad serpentine dike, and a much broader belt is cut by Slate creek in Sierra county. The relations of the two rocks are beautifully shown on the south and west slopes of Clermont hill, and there the contact of the two is everywhere sharp.

It is presumed that there is a genetic relation between the serpentine and the amphibolite-schist, but exactly what the relation is, has not yet been determined. It was first shown by Mr. J. S. Diller* that the original rock of this serpentine dike was a peridotite or allied rock, and the writer found some pyroxenite in the middle of the dike on the ridge to the south of the middle fork of Feather river, and also in Sierra county near Goodyear's creek.

In this serpentine belt to the southeast of Meadow valley at various points are small dikes of a very white rock. The microscope shows these to be made up almost wholly of large grains of feldspar with marked cleavage, and showing occasionally a twin lamella. From the following partial analysis by professor Hillebrand of a specimen from a dike between the junction of Rock and Deer creeks it seems unquestionable that the feldspar is albite:

ANALYSIS OF NO. 455. PLUMAS COUNTY.

SiO_2	66.54
MgO	.77
CaO	.43
K_2O	.89
N_2O	10.28

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*Eighth Ann. Rep. U. S. Geol. Survey, p. 406.

On the Jackson atlas sheet pyroxenite was found altering into massive amphibolite. Some of the hornblende grains contain cores of pyroxene undergoing alteration to hornblende.

DIORITE.

At numerous points in the range are dikes and small areas of fine to medium grained rocks, usually showing to the naked eye abundant hornblende needles. Under the microscope these rocks are seen to be composed of a fine grained groundmass of feldspar and minute brown hornblende needles, through which are scattered larger brown hornblende needles. Occasionally the rock is more nearly granular, the hornblende being in short prisms. In two instances noted the rock contains augite phenocrysts in addition to the hornblende. One of these (No. 155 Amador county) is from a dike-like extension of a hornblende-gabbro area, and is presumably a modification of the same magma as the gabbro (No. 181 Amador county).

Some of these fine grained diorites are nearly or quite identical with a diorite described by Hawes, which is now called camptonite. They appear to be among the latest of the older intrusive rocks.

Near West Point in Calaveras county, at Spanish peak in Plumas county, near Merrimac and Swede's Flat in Butte county, the camptonite occurs as dikes in the granodiorite: near Railroad Flat in Calaveras county dikes of the same rock cut the schists of the Calaveras formation: in the bed of the Cosumnes river to the west of Lamb's bridge (see Placerville sheet) the quartz-porphyrite is cut by dikes of this rock. Some of the camptonites have sometimes been designated hornblende-porphyrite.

GRANODIORITE.

This name was introduced by Mr. Becker for the potash-poor granite of the Sierra Nevada in the general text descriptive of the Gold Belt geological atlas sheets. The rock thoroughly resembles and is usually called granite. It is a holocrystalline rock of hypidiomorphic structure and is composed of plagioclase, quartz, hornblende and brown mica, with a varying amount of potash-feldspar, which is in almost all cases exceeded in amount by the soda-lime feldspar. There are also various accessory minerals. Where the potash feldspar is in large amount the rock might be called a biotite-hornblende granite or a hornblende-granitite; other specimens with very little potash-feldspar are practically quartz-mica-diorite.

The granodiorite occurs in very large areas in the range and is the rock of the Yosemite valley. According to Mr. W. Lindgren the granodiorite at Folsom on the American river has metamorphosed the Mariposa slates into mica-schists; and Mr. H. W. Fairbanks* states that the slates and schists near Bridgeport in Mariposa county (this includes the Mariposa slates) are cut off and metamorphosed by the granite, an observation which the writer later verified. It therefore appears that much of the granodiorite is later in age than the Mariposa slates.

GRANITE-PORHPYRY.

To the east of the granodiorite area of the Yosemite valley is a mass of granitoid rock, in which are developed large pink orthoclase feldspars. About nine miles nearly north of Mount Hoffman, to the north of the Tuolumne river, is a little lake which was visited a few years since by Mr. G. F. Becker and myself, and to it the name of Granite lake was given, partly for the sake of a name to use in notes and partly on account of the magnificent granite exposures about the lake. In fact there is nothing but granite in the vicinity, and as the loose material has been swept away by the glacier that formerly covered the spot, the rocks are beautifully cleaned off. The granite-porphyry occurs about the head of the lake, and the contact there and at other points in the neighborhood with the biotite-hornblende granite is everywhere sharp. Dike-like protrusions of the granite-porphyry were seen extending into the biotite-hornblende-granite, indicating the former to be the younger rock.

The granite-porphyry may be described as a holocrystalline rock of hypidiomorphic structure with a coarse ground mass of plagioclase, orthoclase, and sometimes microcline, with plenty of brown mica, a little primary hornblende, and titanite and iron oxide. In this ground mass are developed large orthoclase phenocrysts, which usually contain abundant inclusions of the minerals of the ground mass, both in the interior and along the edge of the phenocrysts. Plagioclase, biotite, quartz, titanite, and iron oxide were noted in the porphyritic orthoclases, which are often more than two inches in length. It is evident that these phenocrysts were formed after some of the other constituents of the rock, and in this particular the granite-porphyry appears to strongly resemble the porphyrite with large orthoclase phenocrysts described by Mr. Cross (not yet published) as forming a part of the laccolites of the Elk mountains, Colorado. Prof. A. C. Lawson† has lately described a granite-porphyry from the Santa Lucia mountains, in the Coast ranges of California. According to Prof. Lawson, all the quartzes included in the orthoclase phenocrysts of the Santa Lucia granite have a common orientation, with the optic axis perpendicular to the basal pinacoid of the host; and the feldspars have a common orientation by groups. This is not the case with the inclusions in the rock here described. They do not extinguish simultaneously, nor have they any definite position in relation to the area of the host.

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*AMERICAN GEOLOGIST, 1891, p. 211.

† "The Geology of Carmelo Bay." Bull. Dept. Geology of the University of California, vol. I, pp. 1-59.

The granite-porphyry forms a large part of the crest of the Sierra Nevada about the headwaters of the Tuolumne river. It has been noted by the writer at several points to the north of that region, but its relation to the biotite-hornblende-granite or to the granodiorite has not been studied, except near Granite lake. Mr. Becker states that he found the same relation between the granite-porphyry and the hornblende granite, in the district between Highland lakes and Blue lakes in Alpine county, as at Granite lake, and also that, according to Clarence King, granite-porphyry occurs at Mount Whitney.

BIOTITE-HORNBLENDE-GRANITE.

The biotite-hornblende-granite or hornblende-granitite, as it might be called, has a higher percentage of potassa, and less lime, than is normal with the granodiorite; and as its relations to that rock have not yet been carefully studied, it is here given a separate description, although it is part of the great granite area of the Yosemite valley which has there been called granodiorite.

Concretions or segregations in the biotite-hornblende-granite. There are numerous nodules or *schliere*, as they have been called by German writers, in this biotite-hornblende-granite about Granite lake. These are particularly abundant on a vertical bank of granite a little west of Granite lake. The bulk of the rock is the biotite-hornblende-granite (No. 240 Tuolumne county), and both the biotite-hornblende-granite and the *schliere* (No. 239) are cut by dikes or pegmatitic veins of a coarse granite (No. 241). The nodules are composed of feldspar in part polysynthetically twinned, brown-hornblende, and brown mica. There appears to be also a little orthoclase.

Very similar nodules have been described by Arthur Phillips* from granite in the British isles, and by Prof. G. P. Merrill† from the granites of Maine, but in neither case are the constituents of the nodules altogether the same as the constituents of the Granite lake nodules.

Both Profs. Merrill and Phillips consider these nodules to be of concretionary origin and that they do not represent inclusions of foreign rocks altered by metamorphism.

According to F. von Adrian, as translated in Prof. Phillips' paper (p.

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*Quart. Jour. Geol. Soc. Lond., vol. 36, pp. 1-22.

†Proc. U. S. Nat. Museum, vol. VI, pp. 137-141.

3), similar nodules occur in Bohemia and exclusively in the hornblende-granites.

Weathering of the Granite. The granite of the Sierra Nevada weathers in very different ways, producing strikingly different scenic results. According to Mr. G. F. Becker,* the great granite domes of the Yosemite are merely gigantic cases of exfoliation, similar except in scale to those observed in basalt and other rocks. Mr. Becker says:—

"If the theory of an original controlling ball structure were correct, it would account for the spheroidal weathering of the fragments as well as the collosal domes, for between the two extremes of size there is every possible gradation. The large domes show no indication of a tendency to resolve themselves into smaller spheres, excepting when they have first been intersected by fissures."† The surface waters acting along these fissures would produce decomposition, the exposed corners would scale off, and as a result more or less nearly spheroidal bodies would finally result.

Considerable portions of the Sierra Nevada are intersected by systems of fissures more or less nearly parallel. According to Becker,‡ this is a result of pressure from forces acting in definite directions. As a consequence of this, the granite in places possesses a laminated structure which is perhaps nowhere better shown than in Alpine county to the northwest of Charity valley. There are here a set of vertical north and south fissures and another set nearly horizontal. Erosion of the granite produces vertical walls along the vertical fissures and terraces along the horizontal system.

That portion of the crest of the range between Tower peak and Mount Conness is chiefly composed of granite-porphyry, which is intersected by very abundant fissures so that the rock is divided into small polyhedrons of varying shape. As a result the crest here assumes a very serrated outline.

ANALYSES OF GRANITES.§

	Granodiorite. No. 345, Plumas County.	Biotite-hornblende granite. No 19, Mariposa Co.	Granite-porphyry. No. 25, Mariposa Co.
Silica	59.83	72.48	66.28
Alumina	.....	14.06	16.03
Lime	6.49	2.17	3.75
Magnesia	.....	.62	1.12
Potassa	1.69	4.75	3.49
Soda	3.53	3.30	4.10

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*Tenth Ann. Rep. U. S. Geol. Survey, p. 142.

†Mr. Becker discusses the subject more fully in Monograph XIII, U. S. Geol. Survey, p. 68.

‡Bull. Geol. Soc. Am., vol. II, pp. 49-74.

§Nearly all of the analyses contained in this paper were made by Dr. W. F. Hillebrand of the U. S. Geol. Survey.

QUARTZ-PORPHYRITE.

In Amador, Calaveras and Tuolumne counties there are considerable areas of pre-Tertiary rocks usually showing abundant porphyritic-quartzes. These rocks are usually light greenish in color, weathering nearly white. Considerable portions of these areas are schistose, but even then the porphyritic quartzes are usually plainly discernible.

In Calaveras and Amador counties dike-like areas of quartz-porphyrite or quartz-porphyrite-schist were noted in the diabase and amphibolite-schist areas. Some of these are shown on the Jackson atlas sheet. The quartz-porphyrites contain 2.3% to 3.4% of lime, and usually more soda and potassa.

QUARTZ-PORPHYRY.

In Plumas county there are two belts of white-schistose quartzose rocks that do not differ in general appearance from the quartz-porphyrite-schist just described. One of these areas forms a belt a mile or less in width and about twelve miles long, in the Grizzly mountains, lying just east of a belt of argillite that appears to be a continuation of the Grizzly formation of Mr. Diller, which is Silurian in age; the other belt forms the summit of Eureka peak and continues thence south into Sierra county. It is the rock about Wade's lake, where it contains numerous dikes of diabase as previously noted, and of the Sierra buttes. The quartz-porphyry contains usually less than 1% of lime, and as much or more potassa than soda.

The distinction between the quartz-porphyries of Plumas county and the quartz-porphyrites of the Jackson atlas sheet rests on a slender basis of chemical composition and may be discarded later.

The quartz-porphyry of the Grizzly mountains may, however, prove to be Paleozoic in age. This is suggested by its association as noted above, with presumably Silurian argillite. The quartz-porphyry is in part, at least, as late or later than some of the diabase known to be Jura-Trias in age. The long belt extending from Eureka peak to the Sierra buttes is probably Jura-Trias in age, as has been noted under the Milton series.

ANALYSES OF QUARTZ-PORPHYRIES AND PORPHYRITES.

	Quartz-porphyrite. No. 553, Calaveras county.	Quartz-porphyry. No. 323, Plumas county.	Quartz-porphyry. No. 153, Plumas county.
Silica	71.19	73.25	75.06
Lime.............	2.87	2.23	.38
Potassa	1.82	3.79	4.27
Soda	4.24	2.69	3.78

EFFUSIVE IGNEOUS ROCKS.

Rhyolite. The rhyolitic rocks of the Sierra Nevada are chiefly white or pink in color and seem to have issued as flows from various sources, chiefly near the crest of the range. These rocks usually occur overlying the Neocene auriferous river gravels. At Valley Springs peak in Calaveras county, and at other points, they overlie the Ione formation. The rhyolite flows evidently followed the old river channels to a remarkable extent. The exact nature of these flows is not determined. They have been considered as tuffs or mud flows, but in thin sections they frequently show trains of spherulites and other evidences of flow structure. This is the case with some of the rhyolite near Mokelumne hill, which has been spoken of as a tuff.. Occasionally, as at Valley Springs peak, the rhyolite contains pebbles of foreign rock, but fragments of foreign material are, so far as known to the writer, rare in the rhyolite. True tuffs unquestionably occur and some of them may have reached their present position as mud flows.

The rhyolite occurs in massive form as dikes in the granite and schists. One of these (No. 400 Plumas county) is remarkable as containing large amounts of gold in little quartz seams which penetrate the dike in all directions. This dike, which lies about one mile east of Onion valley, at the headwaters of Poorman creek, is much decomposed in the auriferous portion. It is a white rock with abundant foils of brown mica, sanidine and plagioclase, and a few rounded quartzes in a microcrystalline groundmass.

The rhyolite of the Sierra Nevada appears to be all of about the same age. The flows overlie the Neocene auriferous river gravels and underlie the andesite-breccias, and may be early Pliocene* in age.

To the south of Mono lake and just east of the escarpment of the

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*It has been suggested that the clays of the Ione formation have resulted from the decomposition of rhyolite. In this case, since the Ione formation appears to be in part Miocene in age, the rhyolite flows must have commenced earlier than the Pliocene.

Sierra Nevada are some small extinct rhyolitic volcanoes perhaps of Pleistocene age. They have been described by Prof. I. C. Russell.*

Rhyolite is especially abundant in the foot hills of Amador and Calaveras counties, forming, when it caps the points, the level tops of table mountains, of which Buena Vista and Valley Springs peaks are conspicuous examples. No place has been noted in the foot-hills from which rhyolitic eruptions issued. The occurrences seem always remnants of former extensive areas from other sources.

At Buena Vista peak and other points, a peculiar feature in the weathering of the rhyolite was noted. The exposed surfaces are more compact than the interior, presenting, as a fractured surface, a vitreous appearance. This seems to be due to the silica of the rhyolite being leached out by atmospheric moisture and deposited nearly in place. The same phenomenon was previously noted by Mr. Goodyear† at several places.

Andesite. The following varieties of andesite have been noted in the Sierra Nevada:—

1. Hornblende-mica-andesite. This rock occurs in a massive form in two small areas near Grizzly peak, in Plumas county, and at other points. The rock is light gray in color, of a trachytic aspect, strongly resembling the dacite of the Lassen peak region, but shows in thin section no quartz phenocrysts. The hornblende-mica-andesite appears to be among the oldest of the Tertiary volcanic rocks. Analysis No. 198, Plumas county.

2. Hornblende-andesite. There are few areas of andesite in which hornblende is the only bisilicate. Analysis No. 12, Plumas county.

3. Hornblende-pyroxene-andesite. The andesite that formerly covered so much of the range, chiefly in a fragmental form, may be designated hornblende-pyroxene-andesite, the two bisilicates varying a good deal in their relative proportions.

There is a reason to believe that much of the andesite-breccia issued from fissures near the summit of the range mixed with water, forming vast mud flows which poured down the slopes, displacing the rivers. Undoubtedly many areas of andesite-breccia have been formed subaerially by the explosive action of volcanoes, the lava being thrown out as ashes and fragments, which, falling on the surrounding country, becomes roughly stratified. But this does not appear to have been the mode of the formation of the bulk of the andesite tuff and breccia of the Sierra Nevada. The evidence that the material issued from fissures as mud flows finds confirmation in the canyon of Canyon creek at Poker Flat, Sierra county. Here the canyon has cut into the old peneplain to the depth of fifteen hundred feet, right across one of these old fissures, exposing the dike-like mass of fragmental andesite mixed up with fragments of the pre-Cretaceous wall rock, which is largely serpentine. This fragmental material forms also the bed of the creek, where the stream crosses it. Some years ago a shaft was sunk near the creek in this breccia to the depth of about one hundred feet without a change of rock, according to a miner who lived there at the time. Portions of this dike-like mass are stratified, the layers dipping at an angle of from 10° to 15°.

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*Eighth Ann. Report, U. S. Geol. Survey, p. 378.

†See Auriferous Gravels, p. 520.

The composition of the andesite forming the breccias of the Sierra probably varies more or less. The partial analysis given (No. 69, Plumas county) is from a boulder in the breccia, two miles northeast of Laporte.

4. Pyroxene-andesite. This rock is represented on the Downieville sheet by two areas on the ridge south of Grizzly peak. It is microscopically a light gray, medium grained rock (No. 308, Plumas county). Under the microscope it is seen to be made of plagioclase, augite, and hypersthene phenocrysts in an almost crypto-crystalline groundmass of feldspar and magnetite. It thus differs very little in mineralogical composition from such of the dolerite as contains no olivine, but differs in structure in that it has a definite groundmass. It should contain more silica than the dolerite, but no analysis has been made of this rock. It greatly resembles the hornblende-pyroxene-andesite, and may be considered merely a variety of that type.

There is also a peculiar eruptive that appears to be later than the other andesites. It is macroscopically a light gray, fine grained rock, with frequently a slaty fracture. Microscopically it is nearly or quite holocrystalline and composed of slender laths of plagioclase, of augite, and of a slightly pleochroic rhombic pyroxene with magnetite grains.

There is a dike-like occurrence of this rock (No. 332 Plumas county) on the east side of Mohawk valley and a little east of the bridge over the middle fork of the Feather river at Denten's. In contact with this dike the Pleistocene lake beds of Mohawk valley dip at an angle of 25° from horizontality. This lava occurs at various points in Plumas and Sierra counties, but has not been noted by the writer elsewhere in the Sierra Nevada. It forms the high point one and a half miles northeast of Goodyear's bar, the ragged crest one mile northeast of St. Charles ranch, and occurs on the southwest slope of Saddle Back, and also one mile south of Deadwood; all of these points being on the Downieville sheet.

A specimen (No. 387 Plumas county) of this late pyroxene-andesite from the area about two miles west of Eureka peak contains 61.47% of silica as determined by George Steiger.

ANALYSES OF ANDESITES.

	No. 69, Plumas county.	No. 198, Plumas county.	No. 12, Plumas county.
Silica	57.32	59.97	60.
Lime	7.13	6.09	6.04
Potassa	1.39	1.35	1.44
Soda	4.14	3.98	3.35

Older Basalt. This older basalt is a dense black rock showing macroscopically no porphyritic constituents except occasional olivines. It is frequently roughly columnar, the prisms being small, seldom more than three or four inches in diameter. This rock has nowhere been seen by the writer except in the massive form.

Microscopically the rock is composed of lath-like plagioclase, with more or less olivine and some augite in a ground mass, which is rendered dark by the abundant magnetite. The groundmass sometimes contains considerable glass and frequently grains and prisms of augite. Much of the olivine is altered to serpentine. The plagioclases are usually small and of nearly even size. One slide from the basalt of the Mooreville ridge at the Dodson hydraulic mine shows comparatively little magnetite, and is nearly holocrystalline, with a few porphyritic plagioclases and olivines. The rock at this locality is interesting, from containing abundant crystals of chabazite in cavities. Although differing in microscopic character at different points, the rock is never coarse grained and always dark in color.

So far as known to the writer this older basalt only occurs in Plumas and Butte counties. It is the lava of the Walker plains in Plumas county and also occurs to the north and south of Onion valley creek, and in small areas at numerous points. In Butte county it caps the Mooreville ridge and several ridges to the north of that ridge, also Oroville table mountain and Kanaka peak: and at all of these places it rests upon Tertiary deposits, chiefly auriferous river gravels, or upon the pre-Tertiary bed rock. It forms the lava of Iron canyon of Chico creek, apparently resting there directly on Cretaceous sandstone of the Chico formation. The basalt above described is older than the hornblende-pyroxene-andesite-breccia.

The black lava capping the Millerton table mountain in Fresno county resembles macroscopically the older basalts of Butte and Plumas counties.

The basalt of the Tuolumne table mountain is also a dark, heavy rock.

but as may be noted below has an unusually high percentage of silica for a basalt. It is also characterized macroscopically by containing numerous cavities and tabular porphyritic feldspars, which are sometimes half an inch long. Microscopically the table mountain basalt shows large, tabular feldspars, smaller augites and numerous olivine grains in a nearly opaque groundmass, in which are very abundant feldspar microlites. This groundmass doubtless contains a large amount of magnetite and strongly resembles some of the sections of the older basalt. There is a good deal of brownish serpentinoid substance in the groundmass. The porphyritic feldspars are polysynthetically twinned and have a corroded appearance, due to the abundant inclusions of aggregates of opaque particles, with some glass inclusions. There is also some serpentine in the large feldspars. The relative age of this basalt has not been determined. Pebbles of hornblende-pyroxene-andesite (No. 165 Calaveras county) occur under a basalt table mountain on the north side of the Stanislaus river, near the Byrne's Ferry bridge. This basalt is doubtless part of the Tuolumne table mountain flow. This would suggest that the Tuolumne table mountain basalt is later in age than the hornblende-pyroxene-andesite-breccia. For convenience, however, it is included here.

Dolerite.—This lava was described under the name of "late basalt"* in a previous paper. It occurs at numerous points in Plumas and Sierra counties. Through the kindness of Mr. J. S. Diller I was permitted to examine a series of basalt slides of the Cascade range collection and found that a considerable number of the basalts to the north of Plumas county are of the same type. The "hypersthene basalt" mentioned by Mr. Diller in his paper on "Fulgurite" from Mount Thielson, Oregon (No. 181 Cascade range collection), is practically identical with some of the dolerite of Mount Ingalls.

Almost all the areas examined by the writer overlie the hornblende-pyroxene-andesite-breccia. In the ravine that heads about one and a half miles south by east from the summit of Mount Ingalls the dolerite is marked by glacial striae, and the pond indicated on the map near this point has been formed by a terminal moraine. It is, therefore, earlier in age than at least the latter part of the glacial period. On Mt. Ingalls it presents the appearance of having issued after the present drainage system had been partially forming, suggesting the age to be Pleistocene.

The rock is macroscopically a medium to coarse grained, light gray rock, sometimes pinkish, with usually large scattered olivines. Under the microscope it is seen to be nearly or quite holocrystalline and to be composed of lath-like plagioclase, augite and magnetite, with occasional olivines and frequently hypersthenes. One of the slides shows a hypocrystalline base containing abundant grains of magnetite, with numerous phenocrysts of plagioclase and augite, and a few hypersthenes and olivines. In general, however, no glass is to be seen.

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*Am. Jour. Sci., vol. 44, p. 455.

The dolerite of Grizzly peak in the slide examined contains no olivine and comparatively little pyroxene. In the slides examined of the dolerite of Penman peak and other areas near that point there appears to be no hypersthene, but olivine in more abundant than at Mount Ingalls.

Other late Basalts.—Occurring usually in small areas are dikes and flows of basalts, some of them probably Pleistocene in age, as for example the columnar dike-like occurrence at Lava peak on the Downieville sheet where the basalt appears to have cut through the Neocene gravel on the ridge about the peak. The age of the little buttes of columnar basalt, and the isolated flows, relative to the other Tertiary lavas, cannot usually be determined, but they are doubtless all of them late Neocene or Pleistocene. The basalts here referred to always carry an abundance of olivine.

Analyses of Basalts.

	Older basalt. No. 276, Plumas county.	Tuolumne Table mountain. No. 36, Sierra Nevada.	Dolerite. No. 311, Plumas county.
Silica	50.56	56.19	53.91
Lime	7.58	6.53	10.40
Iron oxides........	12.44	7.23	7.01
Magnesia	4.07	3.79	5.52
Potassa	2.10	4.46	1.34
Soda.............	2.94	2.53	2.90

The Succession of the Tertiary Volcanic Rocks.

There is a considerable variety of Tertiary volcanic rocks in the Sierra Nevada, but there are only a few general types that have an extensive distribution. The oldest of the series are perhaps the hornblende-mica-andesites, which occur in small areas on the Downieville sheet and elsewhere, but the earliest flows of which the relative age is definitely known are of rhyolite and the older basalt.

Of these two older rocks the rhyolite has much the wider distribution, it being found throughout the Gold belt. The basalt referred to above as the older basalt is, so far as known to the writer, confined to Butte and Plumas counties. That the rhyolite and older basalt of the Sierra Nevada in general underlie the hornblende-pyroxene-andesite, which, in the form of a breccia, covers so much of the range, has been noted in two previous papers.* It appears, however, that the writer was not the first to have called attention to these relations. In a report made to Prof. J. D. Whitney in 1879, Prof. W. H. Pettee† notes that the older basalt was overlain by andesite, and Mr. W. A. Goodyear* reports that the white lava (rhyolite) always underlies the gray lava (andesite).

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*Bull. Phil. Soc., vol. 9, p. 389; and Am. Jour. Sci., vol. 44, pp. 455-459.

†Auriferous Gravels, p. 468.

Mr. Diller† has described some fragmental volcanic beds which cover large areas in Butte county as the Tuscan formation. This tuffaceous formation consists in part of breccia and resembles, in a general way, the andesite breccia areas further south, but it appears to consist in part of basaltic material of the type of the later basalt or dolerite. The exact relation of the Tuscan formation to the andesite-breccia areas of the Gold belt therefore remains to be determined.

The relations of the older basalt to this tuff is shown in the Iron canyon of Chico creek, where the older basalt (No. 1, Butte county) rests directly on Chico sandstone, and underlies the Tuscan formation.

I also obtained confirmation of this relation by finding pebbles of the older basalt under the tuff at two points, one (No. 15, Butte county) from a tunnel about three miles southwest of Nimshew, and another (No. 52, Butte county) from a little butte about one mile west of Pentz post office.

The relation of the later basalt or dolerite to the andesite is evident on Mount Ingalls. It is plainly later than the andesite. It forms the summits and slopes of Mount Ingalls down to, and in places below, the 7,000 foot contour, and evidently poured forth from the volcano as a molten flood of lava covering the andesite breccia and other rocks. The dolerite may be seen capping the andesite on Penman peak, Mount Jackson, Big hill about three miles northwest of Mohawk valley, on the ridge one-half mile northwest of Bell's bar, and at other points.

The flow of dolerite one mile southeast of Penman peak appears to have taken place after the andesite areas had been much eroded, and the slopes of the mountains were approximately as they are to-day, suggesting that the age of the dolerite flows is post-Tertiary.

Since many of the mortars found among the gravels of California, which have led to so much discussion as to the age of man in that part of the world, are of volcanic rocks, it follows that in investigating these evidences of prehistoric man, the anthropologist may in some cases get some evidence as to their age from the kind of rock composing the mortar.

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*Auriferous Gravels, p. 522.

†Descriptive text, Lassen peak sheet.

Two of the mortars collected by the writer are of hornblendic andesite, probably the hornblende-pyroxene-andesite. If these had been reported as occurring under rhyolite, a reasonable doubt might arise as to the genuineness of the occurrence in light of the succession above indicated.

A RECONNAISSANCE OF THE ABANDONED SHORE LINES OF GREEN BAY.

By F. B. TAYLOR, Ft. Wayne, Ind.

During June and July, 1893, an excursion was made along the shores of Green bay in Wisconsin and Michigan with the object of locating, if possible, the upper limit of postglacial submergence in that region. Dr. F. Savary Pearce of Philadelphia accompanied me during the first half of the season, including this trip and several others of which accounts will be given separately. I had learned from conversation with professor Chamberlin of the existence of abandoned shore lines about Green bay, but had no definite knowledge concerning them. Mr. Leverett had previously explored a part of the coast of lake Michigan, but his investigation did not extend north of the Illinois state line. He found several terraces, but none of them belong to the age of the great submergence here described, as will appear later.

In this investigation our efforts were confined chiefly to the location of the highest shore line. Lower lines were noted wherever seen, but no particular effort was made to trace them. The principal reason for this is that the highest line marks the maximum of submergence and may, therefore, be more safely extended than any lower line by inference from place to place where not continuously traced. For this reason it is also a more reliable index of deformation. Wherever the full extent of the shore line is known it constitutes an absolute criterion for the determination of the amount of change of land attitude. No lower shore line can be relied upon for such an inference unless it is traced with absolute continuity, or unless it has some marked peculiarity which makes its identity from place to place a matter of safe inference. But the highest shore line need not be continuously traced. For, if its identity is thoroughly established in each separate locality, its extension by inference between those localities is safe enough, provided the distance be not too great. With lower lines there is much more liability of error, for they are not always continuous even where locally strong. In the present state of investigation in this country, and especially in the rough and wooded regions of the north, continuous tracing for long distances cannot be expected. The best work that can be done must necessarily be fragmentary and of the nature of a reconnaissance. In the accompanying sketch map the present shore line is represented by a dotted line, except from Two Rivers southward, where it is a continuous line. The heavy lines represent the highest shore line at places observed, and the light broken line its probable extension.

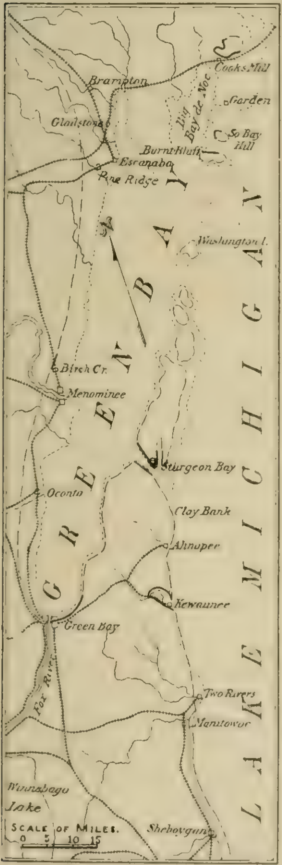

Fig. 1. Map of Green Bay. Scale, about 40 miles to an inch.

Sheboygan and Manitowoc. At these two places, which were the first ones visited, the evidence found was entirely of a negative sort. We drove north and south along the shore from each place and over some of the higher ground back from the lake. The shore at both places is a great fresh bluff of glacial drift, composed mainly of yellow clay with some intercalated layers of sand, but with very little coarser material. In some places the bluff rises steeply from the lake for 90 feet or more. That the lake is cutting it back at the present time is quite plainly shown by the freshness of the face of the bluff

The sods of the fields at its border overhang and vegetation is almost entirely absent from its front. About two miles south of Sheboygan the plateau of drift descends gradually to the level of lake Michigan and merges into a swampy tract. The lakeward front of this swamp is bordered by a beach ridge of gravel, covered by more or less wind-blown sand. This ridge is narrow and the gravel is not above the present reach of the waves. No evidence of a shore line was seen on the slope above the swamp. Northward from Sheboygan the fresh cut bluff extends out of sight. The low flat south of the Sheboygan river, upon which part of the town is built, suggests a corresponding shore line at that level, but no other evidence of it was found. At the east end of St. Clair street there is a terrace, which has been largely modified by recent improvements. It probably corresponds to a shore line at some time in the early postglacial history of the lake, but no other evidence of such a line was seen.

At Manitowoc the shore presents the same appearance of freshly cut bluffs of glacial clay. For 100 to 200 yards off shore at both these places the lake is shallow, suggesting the existence of submerged terraces. North of Manitowoc the bluff becomes much lower. At one place where a small stream enters near the town the low bluff is composed of bright red clay, upon which the waves of the present lake have thrown up a considerable quantity of white limestone pebbles. At Two Rivers, about six miles northeast, the bluff passes inland, and the shore becomes a wide, sandy plain close to the level of the lake. This plain projects into the lake as a blunt point and is no doubt in part a delta of the two rivers.

Kewaunee. Fresh bluffs of clay extend along the lake shore here the same as at the places already described. But the Kewaunee river has extensive flats, which are only slightly above the level of the lake. At the town they are about three-quarters of a mile wide, and along the north side against the foot of the high bluff is a distinct cut terrace about fifteen feet above the level of the lake. The face of this bluff is apparently in a stable condition and east of the road is mostly covered over with a clean turf. At the lake front the bluff projects southward in a sharp point, fresh outside and old inside. About a mile and a half west of the town, where the railroad ascends from the swamp to the higher ground, it crosses a gravel ridge with a lagoon hollow behind it. We did not have an opportunity to examine this ridge with care, but it is probably a true beach, for it faces toward the open lake and its crest is about twenty feet above that level. These two forms were the first positive evidences of postglacial submergence observed on this shore. Along the open lake shore near the town, however, modern wave action has entirely removed this beach. The flats of the Kewaunee river extend inland about five miles. Apparently the valley was excavated by the river when the water of the lake stood at a lower level than now and it was filled up with fine sediments at a later period, when the lake stood at or near the level of the shore line described.

Green Bay. This place is about twenty-six miles west and six miles north of Kewaunee, and the shore line was found at about the same level. Near Bay Settlement, about four miles northeast of Green Bay, we found the beach developed as a cut terrace against the base of the high and heavily drifted coast. Within the eastern limits of the town the beach occurs in the form of low sand ridges, which are well developed at several localities. A very distinct one is not far below the mill at the foot of the hill northeast of town. It is about fifty feet wide and four or five feet above the surrounding plain. On the west side of Fox river the country back of Fort Howard slopes upward to the west very gradually. On this slope we did not find the highest shore line clearly developed, only a few faint sand ridges remaining as evidence of submergence. We ascended the hill east of Green Bay about 150 feet, but saw no evidence of submergence at higher levels.

Sturgeon Bay. At this place we found a fine series of deserted beaches, the crest of the highest being about thirty-five feet above the lake. The highest beach is a finely formed shingle ridge, composed mostly of limestone pebbles. This beach is not very heavily developed and is rather narrow, but it is remarkably distinct and extends for a distance of five and a half miles toward the northwest, to a precipitous limestone cliff half a mile beyond the house of Mr. Roberts. The lake shore drive follows the top of the ridge for a considerable part of the distance. The lagoon hollow behind is very distinct at many places. In a few places, as at the cemetery, the beach becomes a light cut terrace, and for two short spaces it is a ledge of bare limestone. In one place the road passes through a typical boulder pavement which covers the sweep below the beach. The ridge is not far from the present shore of the lake, but the intervening slope, which is rather steep, is covered with a series of light terraces and beach ridges which are quite distinctly developed in many localities. The upper ridge is easily traced through the lots of the village. The public school and court house are both built upon this ridge, or rather upon a part of it which forms a blunt spit projecting southward from the higher ground. From the court house the beach turns away to the north up the west side of a small valley which extends several miles northward into the peninsula. The beach fades away in that direction, but appears again on the east side of the valley. On the drive from Sturgeon Bay to the Life Saving station, which is at the east end of the ship canal, we found the upper beach again about two miles farther east on the eastern slope of the ridge which separates the small valley from the lake. At this point, however, the road passes into a dense thicket and follows a very winding course so that the exact location of one or two points where the beach was seen is not known. For about an hour and a half we were lost on the old lumber roads of the thicket and during that time we crossed well formed beach ridges in two or three places. The ship canal, which is about a mile and a quarter long and connects Sturgeon bay with lake Michigan, was excavated at its deepest cut through about thirty feet of gravel and sand. From an examination of the material thrown out, it seemed evident that the whole depth of excavation was from a deposit of shore drift built into the former strait by the waves of the lake when it stood at higher levels. The coast bordering the lake in that vicinity is a mass of dunes, and it is of this character for a distance of one to two miles back from the shore. At Sawyer, on the opposite side of the bay from the town of Sturgeon Bay, the ground is much more uneven. Several fragments of the shore line were seen there, but it was not continuously traced. In one place near the village a small knob of red clay drift had evidently been an island when the water was at its highest level. It is surrounded by a distinct cut terrace with sea-bluff above. This little island was not more than 200 or 300 feet in diameter. From Sawyer the beach passed about straight south at the rear of the sand plain to the lake shore at Clay Bank. Westward, along the south shore of Sturgeon bay, the coast is mainly a precipitous limestone cliff, where the beach appeared to have no distinct representative. Above the level of the highest beach the surface of the country on both sides of the bay presents a characteristic rolling glacial topography, upon which no evidence of submergence was found. The upper beach in the vicinity of Sturgeon Bay is not heavy in its development. On the contrary, it is quite light and delicate, though very clear and distinct, and the contrast of topography above and below its level is very sharp. This is noticeable at the houses of Mr. Snyder and Mr. Roberts.

The West Coast. The west coast of Green bay slopes up from the lake so gradually that its surface has become a great cedar swamp. The whole coast from Green Bay to Gladstone is bordered by a strip of country like this, from two to six or eight miles wide. The flats back of Fort Howard are prolonged northward along the shore. But at several places between Green Bay and Menominee the railroad rises to slightly higher levels and cuts through banks and mounds of gravel, which I take to be remnants of deltas, for they are found near the courses of the streams. Such gravels may be seen at Suamico and the Oconto and Peshtigo rivers on the line of the North Western railway. We found evidences of submergence back of Marinette and Menominee developed clearly enough up to a hight of about forty feet. But no definite beach marking the highest level was found except at one place near Birch Creek station, about six miles north of Menominee. At that place there is a distinct beach ridge extending north and south along the east base of a rolling drift surface and its altitude is about fifty feet above the lake. There are a great many irregular low sand ridges at lower levels near both these towns, and there are a few dunes. There is a very large dune, or rather a series of them, in the northern part of Menominee near the race course, and there are more about a mile northwest of the town. The evidences of submergence are easily traced westward out Stevenson avenue to the bank of the river above the dam, a distance of about two miles. In passing northward by train the submerged belt is left by the railroad, which ascends to higher levels, at a distance of about seven miles. But afterward several swamps about at the level of the beach are crossed on high embankments. To Escanaba the road passes most of the way over a typical rolling drift country, which has obviously not been submerged. From Powers Junction, which is 284 feet above the lake, the railroad descends again eastward and at Narenta enters a swamp at an altitude of about 120 feet above the lake. At Pine Ridge, about six miles west of Escanaba, there are dunes and also sand ridges at about 110 feet, which seem to be the product of wave action, but in the brief time spent in this vicinity the highest shore line was not definitely located. The country around Escanaba presents the same general appearance as at Menominee. Near Gladstone a steep bluff, gravelly and sandy in its upper part, faces Little Bay de Noc. Its front edge is about 110 feet above the lake, and from the appearance of its upper surface near the front it seems to be the edge of a submerged plain.

Burnt Bluff. The Garden peninsula which separates Big Bay de Noc from lake Michigan ends at the southwest in a high, precipitous cliff of limestone. Near the top of this hill along its north side we found a well-formed beach ridge of shingle at an altitude of about 125 feet above the lake and with a depression behind it. This ridge faces northward over a flat about a quarter of a mile wide and 20 feet lower. The outer edge of this flat is bounded by another beach ridge which extends like a rampart all along its front. A depression extends across the peninsula north of the hill, which makes it certain that the hill was an island at the epoch of submergence. The surface above the highest beach is composed of a clay soil, which was not found in exposed places below; and the topography is in long, gentle slopes, apparently of unmodified glacial origin. At 50 feet above the beach we had not reached the highest part.

South Bay Hill. Passing northward from Burnt Bluff the road goes along the shore of a bay, most of the time at an altitude of 30 to 50 feet above it. A number of sandy beach ridges and small dunes were observed along this shore, reaching up to 40 or 50 feet above the lake. One of the most attractive spots on the Great Lakes is this little harbor at Fayette, an abandoned furnace town. It was formerly, and very appropriately, called Snailshell Harbor. It is formed in part by the northward extension of a gravelly spit from the end of a projecting reef. The opening is toward the north. On the east side of the harbor there is an overhanging wall of limestone about eighty feet high. Back of the top of this cliff there is an extensive level plateau at about 100 feet, and along its edge, about fifteen rods back from the cliff, it is bordered by a rather irregular beach ridge, formed apparently of fragments torn from the front edge of the cliff and thrown up by the waves. Many of the fragments are angular. The flat itself looked as though it had been washed over. Parts of its surface and of the slopes farther north are literally paved with slabs of limestone.

Two miles east of Fayette is South Bay hill, which is nearly as high as the hill at Burnt Bluff. Near its top we found a distinct beach ridge, forming a sharp point projecting toward the northwest. Toward the south the ridge is replaced within a quarter of a mile by a low sea-cliff of limestone, which faces west. Near the point the beach forms an acute angle, and the road crosses it first from the south, passes along about 300 feet in the lagoon behind the point, and then crosses the beach again to the lower ground on the northeast. The altitude of this beach is about 135 feet. As at Burnt Bluff, there is a lower shelf which is bordered by a barrier beach ridge. It is only about ten feet below the highest beach, and the ridge which borders its western front appears to join the front angle or point of the highest beach as a spit formed at a slightly lower level. The ground above the level of the highest beach presents the same characters as that on the top of Burnt Bluff hill and appears to be an unmodified surface of drift. But this island was neither so high nor so large as the other. About four miles north of South Bay hill is another plateau not so high, not high enough to be an island. Light beach ridges were observed along its eastern slope at about 75 and 100 feet, and for a long distance along its eastern edge there is a strong beach ridge at about 110 feet. This hill is called

Garden Bluff hill, and the descent from the beach to the bed of Puffy creek below is 75 or 80 feet and quite steep. At Van's Harbor there are some light fragmentary beaches on the south slope of the hill north of the village at about 30 feet above the lake. On the top of the hill, at about 90 feet, there are also faint evidences of wave action. About a half-mile north a small knob, partly on the land of Mr. Deloria, rises 30 to 40 feet higher, but it was not closely examined. The road from Garden northward crosses a great rolling sand plain about ten miles wide. This plain begins near Jack's bluff, which is about six miles north of Garden and rises steeply from the shallow water of the north end of Big Bay de Noc. The hill is composed of fine gravel which gives a strong impression of wave wash. Its summit is nearly 150 feet above the lake, but no distinct shore lines were found upon it.

The plain appeared to be composed almost entirely of wind blown sand and is heaped up in great rolling ridges of dunes, some of which rise to an altitude of more than 200 feet above the lake. In some of the hollows, especially along the borders of two small ponds, gravel was found, suggesting that the sand may be largely underlaid by that material. On approaching the railroad heavy ridges of gravel were crossed, some of them resembling beaches, but none observed were distinctly of that form. North of the gravel ridges, clay drift with limestone slabs again appeared.

Cook's Mill. At this place several rough and irregular hills of drift rise to a considerable hight out of the sand plain. On the south side about half a mile north of the station we found low beach ridges of fine gravel at an elevation of about 170 feet above the lake. In two places where the road rises to a level higher than this beach the composition of the hill was found to be waxy boulder clay. The area of sand and gravel forming the plain is at this place continuous up to the level of the highest beach. The hill rises about 60 feet above the highest beach, and from the top we could see that the hill extends northeastward at least two or three miles. This hill formed another link in the island chain which represented the Garden peninsula at the epoch of submergence. No doubt there are more hills of this sort toward the northeast belonging to the same series, but it is not known that any of them were high enough to be islands.

Northward from Gladstone the country is wild, and where it is not a swampy sand plain it is a dense forest. Evidences of submergence were seen from the train for a considerable distance northward. Where the railroad attains the level of the sand plain, a few miles northwest of Gladstone, it is about 130 feet above the lake. At Brampton the lower ground has plainly been submerged for two miles north and south from the station. By the profile of the North Western railroad, the altitude of Brampton above lake Michigan is 159 feet. North of this, Maple Ridge is 378 feet; Lathrop, 460 feet; Helena, 526 feet; Swanzey, 646 feet; and Forsyth, where the sand plain ends and the railroad passes into the mountains, is 736 feet. The general appearance of submergence seemed to extend for some distance north of Lathrop, but no evidence of a shore line was seen. The sand plain rises pretty rapidly toward the north and abuts against the rugged crystalline hills of the Mineral range and surrounds its outlying rounded knobs as perfectly as if the sand were a body of water. North of Lathrop the plain becomes very much pitted and holds many small lakes and ponds. Subsequently the highest shore line was found on the hills back of Marquette strongly developed at an altitude of 590 feet above lake Superior. But a distinct beach marking the highest level of submergence was not seen on the slope south of the mountains. In the following table I have presented a list of the principal localities observed, with the altitude above sea level of the highest shore line; or, where that was not found, the highest observed evidence of submergence. The measurements were all by aneroid and are, therefore, only approximate. Those near railroad stations or the lake shore, however, are probably fairly accurate. The letter *t* stands for terrace and *r* for beach ridge.

Level of lake Michigan (U. S. Lake Survey)		582
Beach southward from Two Rivers, Wis.		582
Two Rivers (about lat. N. 44° 10′)		582
Kewaunee	t	597
Green Bay	r	602
Sturgeon Bay	r	617
Birch Creek, Mich. (6 miles north of Menominee)	r	630
Burnt Bluff	r	705
South Bay hill	r	715

Pine Ridge (6 miles west of Escanaba)	r	690	+?
Gladstone	t	700	+?
Cook's Mill	r	750	
Brampton		740	+?
Marquette	r	1190	

These facts show a rather exceptional case of deformation. Taking the altitude of Cook's Mill and that back of Marquette, which is about 42 miles farther north, the northward rise of the highest shore line appears to be about ten and a half feet per mile. This is more than twice the rate which has been established thus far at any locality. There is also a westward component of distance, amounting to about 48 miles, and considering that Lawson's highest beach at Sault Ste. Marie is 1,014 feet above sea level, or about 175 feet lower than that at Marquette, it seems likely that the highest beach has a westward component of elevation from Cook's Mill.

The highest beach of Green bay shows one feature, which is the same as that described in a previous paper relating to the shore lines of the east coast of lake Michigan.* It was found there that from a point located at or near Petoskey southward the highest beach rises to the north at the rate of a little more than six inches per mile, but that from Petoskey northward to Mackinac island it rises at the rate of about three feet per mile, showing apparently a rather sudden change in its plane. From Mackinac to Sault Ste. Marie the northward rise is about four and one-third feet per mile, but it is not known that the change of rate is so abrupt. On the west coast the change of rate is not so great along the southern part, but it is much greater toward the north. The northward rise from Two Rivers to Birch Creek, in a northward distance of about 73 miles, is about eight inches to the mile, and the intermediate stations observed are very close to this plane. From Birch Creek to Burnt Bluff the northward component of distance is about 34 miles, and the northward rise about two feet and two inches per mile. From Burnt Bluff to Cook's Mill the northward component of distance is about 19 miles, making the northward rise about two feet and four inches per mile.

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*"The Highest Old Shore Line on Mackinac Island," Am. Jour. Sci., III, vol. xliii, pp. 210-218, March, 1892.

One of the most important points to be determined in this vicinity is the altitude of the highest shore line on Washington island and on the northern extremity of the peninsula south of the "door." These places are not readily accessible, and being under some necessity of economizing our time we were obliged to pass them by. If the plane of the beach as determined at Birch Creek, Sturgeon Bay, Kewaunee, and Two Rivers, be projected southward at the same inclination it will pass under the present level of the lake along the submerged terraces in front of Manitowoc and Sheboygan. By a comparison with the shore line on the east coast, the beach on the west side, excluding the Marquette observation, appears to be as a whole about 20 to 30 feet lower in the same latitude. The terraces observed by Mr. Leverett farther south probably mark the shore of lake Michigan during the activity of the Chicago outlet. Those in the basin of the Fox river and Winnebago lake probably mark the margin of a glacial lake at the time of the retreat of the ice-sheet. It is at least certain that those terraces are entirely above the level of the clearly defined beach here described.

AMERICAN SPECIES OF AUTODETUS AND SOME PARAMORPHIC SHELLS FROM THE DEVONIAN.

By John M. Clarke, Albany, N. Y.

Autodetus is a term proposed by Lindström in 1884* for a small, attached and sinistrally coiled shell, abounding in the Silurian (=Upper Silurian) strata of the island of Gotland. Originally described from the faunas of Oesel, under the name *Capulus calyptratus* Schrenck,† the only known European species had become quite generally recognized as a characteristic Silurian fossil. In the same year that Lindström introduced this generic term, Quenstedt proposed to designate the same shell by the generic term *Anticalyptraea*‡ and the citation of this name by Lindström attests its publication before the issuance of the latter's work. Though Lindström described this fossil as a molluscan shell and placed it under the gastropodous family *Phoridæ*, he indicated in his description its affinities with certain annelidan tubes, especially as evinced by the shell in its immature condition, before any part of the whorls becomes wholly free from its host. Paul Fischer, also, though allowing the genus to remain in close association with *Xenophora*, speaks emphatically of its annelidan affinities, at the same time suggesting that many of the *Vermetidæ* are similarly attached by the apex.*

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*On the Silurian Gastropoda and Pteropoda of Gotland, p. 185.

†Uebersicht des Schichtensyst. Liv. und Esthl., p. 83, 1854.

‡Handb. der Petrefactenkunde, 3d Ed., p. 673.

That the Swedish author finally surrendered his opinion of the molluscan nature of the shell may be inferred from the appearance of *Autodetus calyptratus* among the Annelida, in a "List of the Fossil Faunas of Sweden; II, Upper Silurian, 1888," page 6.†

Until the publication by the writer of a preliminary list of some Lower Oriskany fossils from Columbia county, N. Y.,‡ the genus *Autodetus* (we prefer to employ this name as little doubt can be entertained that the fossils are worm-tubes, and the use of Quenstedt's *Anticalyptræa* would perpetuate the conception of their molluscan affinities) had not been recorded as occurring in American faunas. There are, however, two species of the genus known in the New York faunas, one occurring in the Lower Oriskany fauna of Becraft's Mt. (*A. beecheri*), the other in the Hamilton shales (*A. lindstrœmi*).

In noting the continuance of this generic type from the Silurian into the Devonian faunas the opportunity is afforded of adding something to what has been known of the structure of these bodies.

The shells have the form of a truncated cone, whose exterior is smooth, seldom showing any trace of the internal coil, though covered with a fine undulose and sometimes rugose concentric striation. The apical extremity is flattened into a broad cicatrix of attachment, which sometimes has one-half

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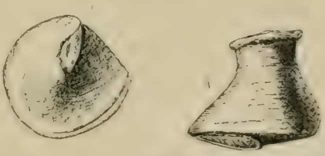
*Manuel de Conchyliologie, p. 760, 1887. It may be observed that Jackson states (Phylogeny of the Pelecypoda, p. 320) that in young *Vermetus* the shell is regularly coiled and unattached, deflection of curvature in the whorls taking place only after attachment has been effected.

†"Edited by the palæontological department of the Swedish State Museum."

‡Notice of a new Oriskany fauna in Columbia county, N. Y., by C. E. Beecher; with an annotated list of Fossils, by J. M. C. Amer. Jour. Science, Vol. XLIV, pp. 410-414, Nov., 1892.


Figs. 1, 2. Umbilical and lateral views of *Autodetus lindstrœmi*, showing the apical cicatrix and the sinistral volution. x3. Hamilton shales: Hamburgh, N. Y.

the width of the body-whorl. The attached surface is thickened or irregularly wrinkled, bearing some trace of the external markings of the host, which in every case where the supporting surface has been retained, proves to be a brachiopod shell. The early whorls of the tube which are involved in the shell substance are not visible on this cicatrix, as they are in some other attached annelids, e. g., *Spirorbis*, but this is undoubtedly due to the thickening of the shell about its support. It is probable that young shells, if they could be detached, would show these sutures. Lindström has observed the tendency of the basal or apical portion of the shell substance to spread laterally, or even to form short radiciform extensions, as in some of the corals (*Omphyma*), the attached pelecypods (*Hippurites*), and brachiopods (*Richthofenia*). This latter structure has not been observed in our species, though the thickening and spreading of the shell at the cicatrix is always noticeable. In a longitudinal median section of the shell, as shown in the accompanying figure of *A. lindstrœmi*, we find evidence of a very considerable thickness of the walls of the sinistrally coiled tube, and this thickness is palpably greater about the earlier whorls. There is also a certain looseness or cellular character in the shell substance, noticeable wherever the deposit is greatest, as at the edges of the cicatrix, at the periphery of the body-whorl, and especially between the whorls and the solid columella, where there are considerable cavities, crossed by distant and delicate lamellæ. In figure 6, which is an upper or umbilical view of a larger specimen of the same species, from which the interior portion of the last volution has been broken, the thickness of the outer wall is exposed and this appears to be more or less cavernous. This loose texture or cellular structure is quite in accord with that of all attached annelidan

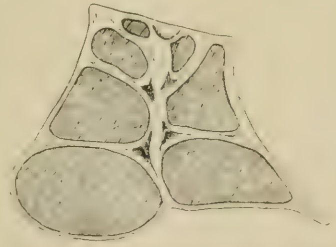
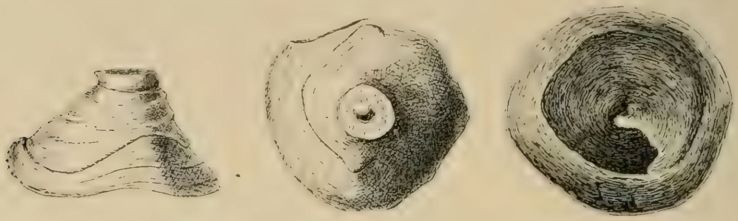


Fig. 3. A longitudinal median section of *Autodetus lindstrœmi*. x5.

tubes (*Cornulites*, *Conchicolites*, *Serpula*, etc.); and the observations by Jackson[*] upon the effects of attachment in the pelecypods would lead to the inference, borne out by the evidence afforded by the brachiopods and such annelids as these, that such shell-structure is not merely a concomitant of this solid fixation, but a result of it.



Figs. 4, 5, 6. Lateral, apical and umbilical views of *Autodetus lindstrœmi*. x3. Hamilton shales, Canandaigua lake, N. Y.

It will be further observed that the whorls in these shells are but slightly oblique, and in completed individuals these appear to have numbered four and one-half or five. Some of the specimens of *A. beecheri*, preserved as external and partial internal casts, afford facts bearing upon the mode of early growth of the shell. Figure 7 represents a very young shell, which is in no respect unlike forms of *Spirorbis* at a corresponding growth stage. The nuclear end is very obtuse, the surface of the primary whorl becoming abruptly and extremely convex, while the aperture is depressed and its outer margin greatly produced. At this stage and for a considerable subsequent period in the growth of the shell there is no envelopment of the whorls, the mode of growth being in all respects like that of *Spirorbis*, fixation being effected only by the attachment of the lower surface of the whorls. This is seen in figure 9, a view of the internal cavity of the cone in which an internal cast of the early whorls is retained. With the formation of the volution next succeeding those represented by this cast, the plane of the volution becomes elevated above that of the earlier whorls and the conical form of the mature shell has

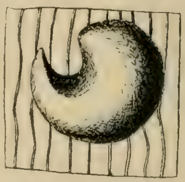


Fig. 7. A very young shell of *Autodetus beecheri*. x8. Lower Oriskany, Becraft's Mt., N. Y.

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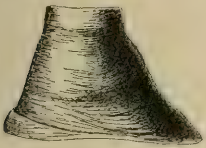
[*] Phylogeny of the Pelecypoda: Mem. Boston Society Natural History, vol. IV, p. 322, 1890.

therein its inception. Had the early mode of growth been perpetuated, a planorbiform but sinistral shell attached by the upper margin of each whorl, would have resulted, or such a shell as is often presented by *Spirorbis*, where the sudden deviation in curvature does not occur. The same deflection in curvature which characterizes the later growth-stages of most forms of *Spirorbis* was undoubtedly, in *Autodetus*, an efficient cause in producing the conical form of the shell in post-infantine stages.



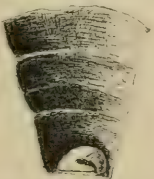


Fig. 8. Lateral view of *Autodetus beecheri*. Fig. 9. An external cast preserving at the apex the filling of the primary whorls. x 3. Lower Oriskany, Becraft's Mt., N. Y.

The sutures rarely leave any trace upon the exterior, though when there has been a slight compression of the shell the course of the whorls may be traced from without, by a low spiral undulation.

The formation of a columella is a peculiar feature of this genus, due to close coiling and the same hypertrophic exudation of testaceous matter which has produced the thickened cicatrix and outer walls and has obliterated the sutures.

In 1865 Billings described* from the base of the Ordovician (Quebec group) a conical, sinistral shell, to which he applied the name *Clisiospira* (*C. curiosa*). There is little known of the species, save that it is not attached at its apex, that the first two or three volutions of the spiral are clearly defined by an external suture, and that the body whorl is broadly expanded and trumpet-shaped. Billings further states that "the cavity occupied by the animal appears to be, at least in the lower part, not spirally coiled, but straight and central, with the lip spread out all around." Two additional species, which are referred to *Clisiospira* by Whitfield, *C. occidentalis*†, from from the Trenton limestone, and *C. lirata*,‡ from the Calciferous fauna, afford little additional information in regard to the internal structure, except that in the former the suture is, on the internal cast, clearly apparent, even to the aperture.

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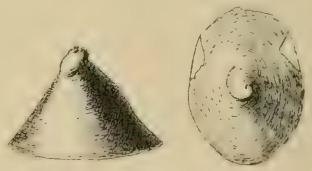
*Palaeozoic Fossils, vol. I. pp. 186, 420.

†Geology of Wisconsin, vol. IV, p. 222, pl. 5, fig. 21, 1884.

‡Bulletin American Museum Natural History, vol. I, p. 308, pl. 25, figs. 16, 17, 1886.

and the dorsal or marginal expansion producing the trumpet form of the body whorl in *C. curiosa* much abbreviated. Mr. Whitfield suggests the resemblance of the shell to a sinistrally coiled *Infundibulum*. In the latter of Whitfield's species the broad dorsal expansion which produces the conical form in the typical *Clisiospira* is wanting, and the shell has more the appearance of a reversed *Capulus* than a reversed *Calyptræa*. As suggested by the author himself, it probably will prove to be a representative of Lindström's genus *Onychocheilus*.

In a fauna of the later Devonian in New York (Intumescens fauna) occur two species of conical shells whose external similarity to forms of *Autodetus* and *Clisiospira* is at once striking. One of these has been found in the concretions of the Naples beds in the Whetstone gully, Honeoye lake, associated with *Clymenia neapolitana*, *Goniatites intumescens*, etc., the other in the Styliola layer of the Genesee shales on Canandaigua lake.* The former is a shell of about the same proportions as the species of *Autodetus* described above, while the latter is of considerably larger size. Both and all are characterized by the fine, irregular, concentric lineation of the external surface, the regularly conical form, and there is almost an agreement in the complete obscuration of the external suture. The Naples species, however, bears a minute external spiral at the apex, which shows no evidence of attachment, and while the shell from the Styliola layer is broken at the apex, both prove to be dextrally, rather than sinistrally coiled shells. Upon examination of the shell substance it is found to be thin throughout, without evidence of columella or testaceous thickening in any part. In the shell whose apical por-



Figs. 10, 11. Lateral and apical views of *Protocalyptræa marshalli*. x3. Fig. 10 slightly restored at the margin. Naples beds, Honeoye lake, N. Y.

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*The writer has shown in various papers that in Ontario and the adjoining counties the earliest appearance of the Intumescens fauna is in the limestone occurring at about the middle of the Genesee shales, known as the *Styliola layer*; disappearing from this region during the interval of the deposition of the upper portion of the shales, it reappears abundantly developed in the Naples beds above. (See Bull. U. S. Geol. Survey, No. 16, 1884; Neues Jahrb. für Mineral., vol. I, 1891; AMERICAN GEOLOGIST, vol. VIII, pp. 86-105, Aug., 1891.)

tions are preserved the external spiral is oblique, composed of one and a half volutions, extends for about one fourth the height of the shell and thereupon becomes lost in the abrupt expansion of the next and last volution. The growth of the body whorl is very rapid, giving the shell when viewed from beneath precisely the same character as that possessed by the recent genus *Calyptræa.*

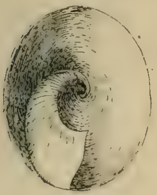

Fig. 12. Apertural view of *Protocalyptræa marshalli.* x3.

In the species from the Styliola limestone, though the apex is lost the form and sculpture are the same as that of the Naples species, and our specimen is broken in such a manner as to demonstrate the dextral coiling of the shell.

These two dextral Devonian shells are clearly gastropodous and their concurrence with species of similar exterior, but with a sinistral coiling, whose nature appears from all the evidence to be annelidan, is at least an interesting coincidence. The former are, however, of still further interest in representing a novel gastropod type for the Palæozoic faunas, differing from *Clisiospira* of the Ordovician in its normal coiling and minute spire, and which it is now proposed to designate by the name *Protocalyptræa.*

So far as I am aware, there is but one other representative of this ancient calyptræid genus recorded from the Palæozoic faunas, namely, the species described by the writer as *Capulus galeroides*, from a corresponding horizon (Intumescens fauna) at Rübeland in the Hartz mountains.* This is a shallower, less conical shell than the American species, with a less conspicuous spiral and a pronounced oval marginal outline, but with similar surface sculpture and internal structure. The occurrence of all the known members

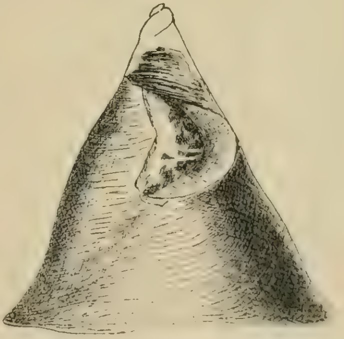

Fig. 13. *Protocalyptræa styliophila.* Styliola limestone, Canandaigua lake, N. Y.

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*Fauna des Iberger Kalkes; Neues Jahrb. für Mineral., etc., Beil. Bnd. 3, 1884, p. 363, pl. 5, fig. 12.

of this genus only in this Devonian fauna, which marks an horizon so clearly defined throughout Europe and in the state of New York, gives to *Protocalyptræa* at once an important value as a geological index.

DESCRIPTIONS OF THE NEW SPECIES HERE DISCUSSED.

AUTODETUS BEECHERI.

Shell a truncated cone; apical cicatrix relatively large, usually less than one-half the diameter of the body whorl. Cone gradually and somewhat irregularly expanding. Surface without external evidence of sutures and marked with irregular concentric growth-lines.

Dimensions of an average specimen: height, 4 mm.; diameter of body whorl, 6 mm.; diameter of cicatrix, 2½ mm.

Siliceous limestones of the Lower Oriskany, Becraft's mountain, N. Y.

(Named for Prof. Charles E. Beecher, of New Haven.)

AUTODETUS LINDSTRŒMI.

This species differs from the foregoing in its usually larger size, more rapidly expanding shell, and greater difference in the relative diameter of cicatrix and body whorl. A full grown individual measures, height, 6 mm.; diameter of body whorl, 9 mm.; diameter of cicatrix, 2½ mm. Hamilton shales. Most of the specimens have been obtained from a locally developed limestone occurring at Tichenor's, on Canandaigua lake; also found in the shales at Hamburgh, N. Y.

(Named for Dr. Gustav. Lindström, of Stockholm.)

PROTOCALYPTRÆA STYLIOPHILA.

Shell comparatively large, regularly conical, apex unknown. Surface without rugous growth-lines, but marked with extremely fine, essentially concentric striæ, as in *Calyptræa.* The dextral volutions very faintly perceptible from without. Dimensions, restoring the broken apical portion from the general slope of the sides: height, 12 mm.; diameter of aperture, 14 mm.

Styliola limestone in the Genesee shales; Genundewah, Canandaigua lake.

PROTOCALYPTRÆA MARSHALLI.

Shell small, conical, rapidly expanding. Apical spiral well developed for about one and a half volutions, thence lost ex-

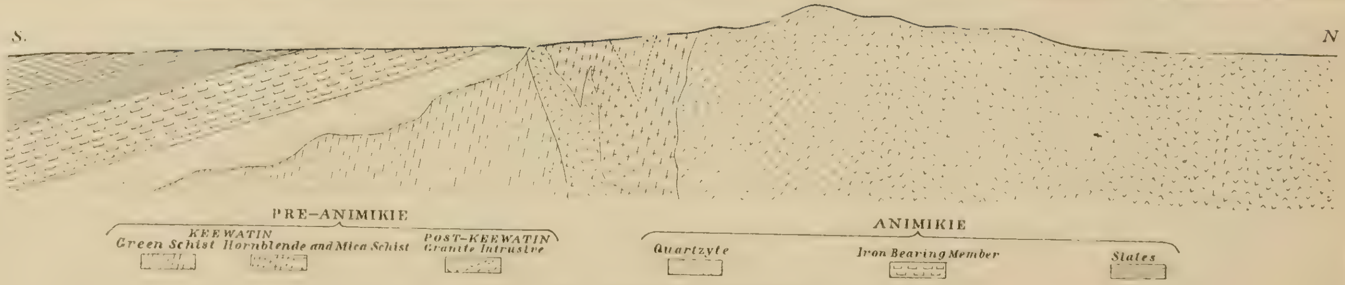

FIG. 1.—SECTION ACROSS THE MESABI RANGE.

Drawn north and south through the middle of townships 58-18 and 59-18, passing through the town of Mountain Iron.

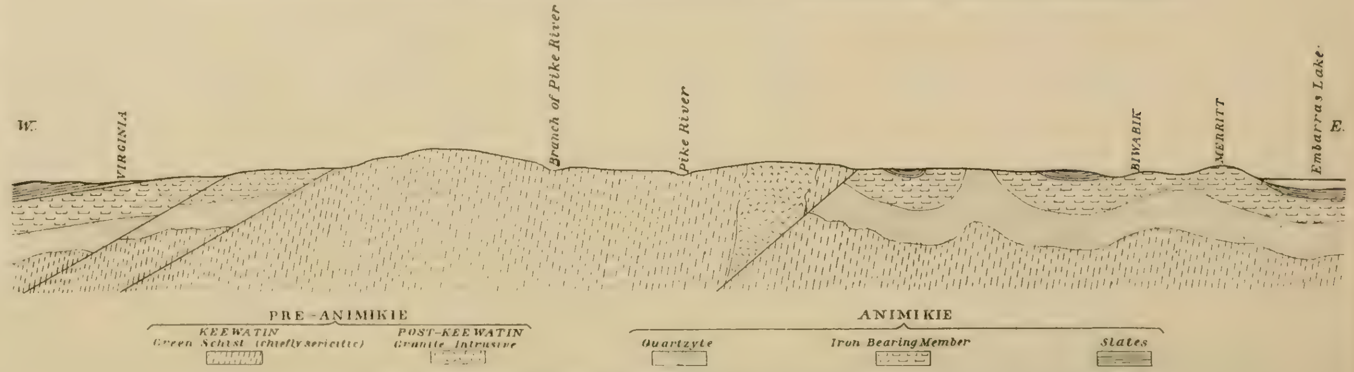

FIG. 2.—SECTION ACROSS THE VIRGINIA AREA.

Drawn east and west through townships 58-16 and 58-17, passing through the towns of Virginia, Biwabik and Merritt.

Horizontal scale of sections, 2-3 inch 1 mile. Vertical representation of strata twice exaggerated; of topography, six times exaggerated.

teriorly by the rapid growth of the body whorl and the expansion of its dorsal margin. Surface very faintly marked by concentric lines. External trace of the suture on lower three-fourths of shell exceedingly faint. Dimensions: height, 5 mm.; diameter of aperture, 6½ mm.; height of external spiral, 1.2 mm. This is the type of the genus.

Naples beds; Whetstone gully, near Honeoye lake, N. Y.

(Named for Mr. W. B. Marshall, of Albany, conchologist of the New York State Museum.)

THE IRON ORES OF THE MESABI RANGE.*

By J. E. Spurr, Gloucester, Mass.

(PLATE VIII.)

Preliminary Note.

The information on which this paper is based was gathered by the writer while in the employ of the Geological Survey of Minnesota. Only an outline of some of the more important results of this study is given here; the full account is contained in Bulletin X of the survey.

Limits of the Mesabi Range.

The Mesabi range in Minnesota may be for convenience separated into three geographical divisions, characterized by sufficient geographical differences: The Western Mesabi, which extends from the Mississippi river to the Embarras lakes, on the eastern edge of range 16 W.; the Eastern Mesabi, reaching from the Embarras lakes to the region of Gunflint lake; and the International Boundary division, which stretches from Gunflint lake east to Pigeon point. In the Western Mesabi region lie all the mines at present worked, and it is to this section alone that the observations made in this paper are intended to be strictly applicable. The chief ore-bearing district lies between the Mesabi Chief mine on the west and the Hale on the east, a distance of about forty miles.

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GENERAL STRUCTURE.

The lowest rocks of the region are greenish schists, which belong in the Keewatin formation.* These schists are cut by a great belt of intrusive granite, which runs the entire length of the iron-bearing district and usually forms the summit of the divide betweeen the Mississippi and the Red river basins. Unconformably upon these older rocks lie the gently dipping Animikie strata.

There are three chief members of the Animikie in the iron-bearing regions, as definitely known at present. Lowest is a quartzyte; upon this lie the iron-bearing rocks; and finally there is a great thickness of black slates. The base of the slates is calcareous, and becomes in places an impure limestone, often dolomitized or sideritized.

The iron-bearing rocks occupy a definite and constant horizon between the quartzyte and the slates. They are marked by peculiar and characteristic features, and have always been recognized as invariably associated with the ore deposits. They seem to have a nearly uniform thickness, which may be estimated as between 500 and 1,000 feet, with an average of perhaps 800 feet. The relationship of these several formations is shown by the section forming figure 1, plate VIII.

MINOR STRUCTURE OF THE ANIMIKIE.

The ore-bearing region of the Western Mesabi affords a peculiarly valuable field for investigation, for the rocks have suffered only very slight disturbance since the time of their deposition. The general structure is a monocline, which dips slightly east of south, at a gentle angle, which averages perhaps ten to fifteen degrees. On the eastern end of the Western Mesabi there has been some slight additional disturbance. There is evidence leading to the belief that a wedge-shaped area eight or ten miles in length, lying mainly in T. 58-17, has been faulted up above the surrounding rocks; the amount of vertical displacement being perhaps 500 feet. This may be called the Virginia area, from the town of that name which is in the vicinity. To the east of this upthrust area there is, as far as the Embarras lakes at least (a distance of five or six miles), a gentle folding of the strata, which appears to have been contemporaneous with the faulting. These disturbances may be provisionally believed to have occurred in later Keweenawan or post-Keweenawan time, and to have been contemporaneous with the monoclinal tilting. Figure 2, plate VIII, is a section from west to east across these faulted and folded strata.

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*The terms Keewatin and Animikie are used by the Minnesota Survey to distinguish formations which, in general, correspond to the Huronian of the United States Geological Survey, the Animikie corresponding to the upper, the Keewatin to the lower Huronian. (See Twenty-first Ann. Rep., Minn. Survey, p. 4.)

CHARACTER OF THE IRON-BEARING ROCKS.

The rocks of the iron-bearing member exhibit great diversity. The most common sort is massive and siliceous, and is thickly spotted with small round darker areas, consisting mainly of iron oxide. From this there are many deviations; and often the different varieties cannot be said to resemble one another in any way, either in the field or under the microscope, or on chemical investigation. But specimens are constantly found which show one variety changing into another. Thus it soon became evident to the writer that all the rocks of the iron-bearing member, however different, were closely allied in origin, and were probably derived from a single primitive type. This same principle has already been shown by Irving and Van Hise for the Penokee-Gogebic rocks.*

NATURE OF THE ORIGINAL ROCK.

A careful macroscopic and microscopic study of a large number of carefully selected specimens was made, with very satisfactory results. Nearly every detail of the changes from one phase into another could be made out and the causes assigned. The changes were seen to be those of metasomatosis, and the inciting agents seemed mainly atmospheric. The original rock of the series was quite unmistakable. Typically it may be briefly described as follows:

In a ground-mass of cryptocrystalline, chalcedonic, or finely phenocrystalline silica, are thickly strewn rounded or subangular bodies, made up chiefly of a green mineral, very slightly pleochroic, and without cleavage; under crossed nicols it appears in some places amorphous, in others extinguishing as an aggregate.

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*Tenth Ann. Rep., U. S. Geol. Survey.

Analyses showed this mineral to be essentially a hydrous silicate of iron, and selected sections kindly examined by Dr. J. E. Wolff, of Harvard University, were stated by him to "resemble in all physical characters *glauconite*." In one especially fresh specimen there were also rounded grains of calcite (probably magnesian), apparently originally detrital, and in some limited areas these increased in number till they formed nearly the whole bulk of the rock. These glauconitic carbonate layers are nearly identical in appearance with the glauconitic St. Lawrence (Cambrian) limestone of Minnesota, of which sections were cut and compared. Dr. Wolff suggested tentatively that the rock was an altered greensand. This appears to the writer to be the correct view. There is, however, a peculiar feature shown by chemical analyses—a constantly very small amount of potash.

The Processes of Change.

It is quite certain that from this rock are derived nearly all the other phases in the iron-bearing member. In the alterations there are various processes, differing by reason of the varying forces which have been brought to bear upon the rocks. The most common, which may be called the *normal process*, appears to take place under scant access of atmospheric agents. The decomposition of the green mineral is the noteworthy event. It breaks up, forming chiefly silica and the iron oxides or carbonate, so that in by far the commoner phases of the rocks the rounded bodies or granules are composed entirely of these decomposition products.

The various stages in the rearrangement of the silica and the iron oxides or carbonate constitute the succeeding phases. The chief cause of their separation lies in the different conditions under which these two chief constituents are taken into solution. From very careful study of the separation and concentration of the silica and the iron, there may be deduced two rules. First, in regions of comparatively free oxidation, chalybeate waters deposit iron and remove silica. Thus bands of iron are formed along cracks and fissures, whether macroscopic or microscopic, replacing the silica; and isolated spots weakened by weathering become by replacement blotches of iron oxide. Conversely, in regions of extremely scant oxidation, waters deposit silica and remove iron in solution. Thus the portions which are most porous become richer in iron and lose their silica; this iron is derived mainly from the adjacent unoxidized parts of the rock, and into these unoxidized parts the silica from the oxidized portions is constantly carried. The final result is an almost complete separation of iron and silica.

Chemistry of the Process.

The chemistry of this process seems to be approximately as follows:

Most atmospheric waters contain, among other things, carbonic acid, oxygen, and certain amounts of the alkaline salts. Carbonic acid gives water the power of taking iron into solution: while the alkaline salts are slower but ready solvents of silica, especially in the finely divided cryptocrystalline or chalcedonic state in which it is usually found in these rocks. These waters find their way into the rock, and to some degree into the firmest portions. As they begin to penetrate inward from the crevice along which they came, the oxygen unites with the unoxidized elements of the rock, decomposing some of the minerals, and extending the *weathered zone*. By the decomposing action of this oxygen, carbonic acid may be set free; and the same product may result from the action of acids, either brought in by the water or developed during decomposition. The water thus passes further into the rock free from oxygen, but highly charged with carbonic acid. Aided by the pressure under which it is placed, it readily dissolves the iron. The affinity of the alkaline solvents for the silica is so much weaker than that of the carbonic acid for the iron that the water becomes saturated with iron, without any appreciable quantity of silica being taken up. The solution finally finds its way again out into a zone of greater oxidation, such as a crack. Upon the access of oxygen and the release of pressure, most of the iron is precipitated. As the solvent power of the water is now renewed, the alkaline salts become able to take silica into solution. Thus iron replaces silica. Next the water again finds its way into an unoxidized region, and under these conditions again takes iron into solution, which compels the precipitation of some of the silica; so that here silica replaces iron. Finally, this process brings about an almost complete separation of the two minerals.

THE CONCENTRATION INTO BANDS.

Most often weak and firm points alternate closely in the rock, usually being arranged in narrow horizontal zones. If the weak zone is one of comparatively scanty oxidation, the iron may be deposited as carbonate: if of freer oxidation, as the hydrous sesqui-oxide. So in the final concentration we may have a very well defined banding of cherty silica with siderite; or, more usually on the Western Mesabi, bands of silica (usually ferruginous), alternate with bands of iron oxide (usually siliceous). The crystallization of the latter gives the typical "jasper and ore," which is occasionally found on the Western Mesabi, but is not so common as in others of the Lake Superior iron regions.

RESULTS OF ACCUMULATED STRAINS.

The change from the oxides of iron to the carbonate, and from the carbonates back to the oxides, has been found by study with the microscope to be very common, and the same iron may repeatedly undergo the metamorphosis, with changing conditions. When the most of the rock is thus altered, there is an appreciable change of bulk, the oxidation of the carbonate being attended by contraction, and the carbonatation of the oxides by expansion of the rock. The loss of the more soluble products of decomposition has also a marked contractile effect, very early in the rock's decay. These contractile and expansile tensions, occurring sometimes in different parts of the field, often successively in the same part, have given rise to many of the physical peculiarities of the rock. Among the effects of the contractile tensions there is a very common smooth, vertical, prismatic jointing, and the development of closely set horizontal joints, which somewhat simulate cleavage. It is these horizontal joint-cracks which become the seat of deposition of the iron from the percolating waters; and thus the parallelism of the banding is explained. With the advance of decomposition, the horizontal cracks become more numerous, and the bands of iron which are formed along them often grow till they unite. It is to this cause that the beautifully bedded character of the ore-deposits must be chiefly ascribed.

The expansile strains lead to breccias, and to local faulting and folding, especially in the ore bodies. They also give rise to shearing movements, which have in many places altered the rocks for a limited distance and induced a schistose or slaty structure. This shearing process forms one of the chief deviations from the normal process of change.

VARIATIONS FROM THE NORMAL PROCESS.

Another important modification of the usual manner of change follows the exposure of a considerable area to freely oxidizing forces. This condition is nearly always found at the surface, and often deep into the rock, following zones of weakness, induced chiefly by regional disturbances. In these parts of the rock the various stages of decomposition and concentration are hurried forward with such comparative swiftness that the phases of rock thereby produced are different from those produced by the normal process. In these rocks the iron is concentrated into large bodies and impure disintegrated silica and clay is left behind. Thus, among the ferrated rocks, the ore-bodies are formed. Among the leached rocks the most common are the "paint rocks," which have, subsequent to their leaching, usually become iron-stained, so that they form a stiff clay, red, yellow or brown in color; also a cream white residual clay, which has been mistaken for kaolin. On analysis the last proves to be mainly free silica, with a small amount of silicate of alumina and impurities; and, in one place at least on the Western Mesabi, it is a nearly pure silica powder.

Least important among the causes of change has been the impregnation of the rocks by minerals apparently derived from without the iron-bearing member and brought by precolating waters. Calcite is the chief of these minerals; and the calcitized portions of the iron-bearing rock are distributed near the contact with the calcareous stratum of the black slates.

THE FORMATION OF THE ORE-DEPOSITS.

It has already been stated that the bands of iron owe their existence to previously formed zones of weakness. From the narrow band there may be found every gradation upward in size, till the body of iron becomes large enough to merit the name of an ore-deposit. These ore-deposits are often very large, being occasionally nearly a mile in their longest extent. The ore is usually hematite, loose and granular, and when of best quality is of a blue or brown color. Typically there is a portion, near the surface, which has become hydrated into yellow limonite or göthite. Often these ore-bodies rest upon the basal quartzyte; often again they rest upon the hard and little-altered iron-bearing rock itself. The conditions under which they form seem identical with those necessary for the growth of the narrow bands of iron in the banded "jasper and ore." In both cases the iron has concentrated in an area of especial weakness. In the case of the band the cause of the small area of weakness has already been explained. In considering the cause of the formation of the ore-bodies, it is only necessary to find the cause of the development of so great regions of weakness.

The richest ore-producing region thus far developed is that which lies in T. 58-17, and surrounds the Virginia area, following the supposed fault-lines. Immediately east of these lies another rich group, near Biwabik, in the somewhat disturbed strata adjacent to the upthrust area. At the Mountain Iron mine there is strong microscopic evidence of a disturbance, probably a fault, while at the other important mines there has not been sufficient exploration to enable one to determine their peculiarities. So the conclusion may be reached that the most important of the ore-bodies owe their existence to regional disturbances which have produced large areas of weakness. Faults, especially, are accompanied by the development of such areas, and in folded regions the summits of anticlines, and to a less degree the troughs of synclines, are weakened.

In the opening up of a great area of weakness, moreover, such as attends a fault-plane, a channel for the surface waters to find their way down is often afforded, and the shallow underground drainage for a considerable distance is deflected into the fault-fissure. The increased supply of water, emerging saturated with iron from percolating through the decomposing iron-bearing rocks, is an important factor in the formation of the ore. The chemistry of the process is practically the same as for the small oxidized areas which produce bands. Waters emerge heavily laden with iron into this zone of oxidation; here they precipitate their iron and are enabled to take into solution and carry away some small quantity of silica. The effect of the underlying impermeable quartzyte is important, since it deflects the surface waters into the weak zone, instead of absorbing them. Owing to the crystalline nature of its quartz, it is hardly or not at all replaced by iron, and thus it forms an unaltered stratum, even in the weakened zone, upon which the ore-body may accumulate.

In addition to this, smaller ore-bodies may be formed near the surface, at the bottom of the highly weathered zone, and resting upon the little-altered rock below. Inequalities in the decomposition produce small basins in the hard rock below, in which waters collect and finally deposit their iron.

It may be noted that the impervious dikes, which have been shown by Irving and Van Hise to have been important in the concentration of the iron in the ranges of the South Shore, especially in the Penokee-Gogebic, have played no part upon the Mesabi. Upon the whole length of the Western Mesabi there has not yet been discovered a single dike or other igneous rock in the Animikie.

It must be remembered that in no single case has an ore-body been mined out, or even explored sufficiently to give a complete knowledge of its features, so that much valuable information must come to light in the future.

Date of the Concentration.

These is no positive evidence as to the exact time of the disturbances which ultimately brought about the formation of the great ore-bodies. It may be considered, however, pending evidence to the contrary, that they were contemporaneous with the monoclinal tilting, and that they occurred in later Keweenawan or immediately post-Keweenawan time.

The Eastern Mesabi.

The Eastern Mesabi differs in regard to its iron from the Western Mesabi in that it contains a much larger proportion of magnetite, which is associated with somewhat more crystalline silica. As these peculiarities are associated with the presence of the igneous rocks of the Keweenawan, and since they fade out as the distance from the Keweenawan area increases, it appears probable that, as has been suggested by H. V. Winchell,* the advent of these rocks was in some way connected with the magnetic condition of the iron. If this be the case, we must conclude that most of the banded magnetite of the Eastern Mesabi had become concentrated prior to Keweenawan time. But the lack of large ore-bodies in this region shows that up to this time the concentration had not occurred on a very large scale. It is probable that the same force which produced magnetization put a serious check upon the separation and concentration of the constituents of the rocks, causing the degree of concentration in that region at the present time to be behind that of the Western Mesabi.

THE CRETACEOUS CONGLOMERATES.

There are upon the Mesabi small patches of Cretaceous rocks, lying upon the Animikie strata. In the area examined, they are chiefly conglomeratic, and the fragments are mainly derived from the iron-bearing rocks. A study of these fragments shows two things: first, that at the time of the formation of the conglomerate there existed hard iron ore in the iron-bearing member; and, second, that much of the rock has been decomposed and has had its iron concentrated subsequently to being taken into the Cretaceous beds.

We may conclude that the process of concentration has been going forward since early Keweenawan or pre-Keweenawan time, and there is abundant evidence that it is going on at the present day.

SUMMARY.

The more important points in regard to the ores of the Mesabi which this paper presents are these:

1. The original rock is probably an altered greensand, in which the iron exists in the form of the hydrous silicate *glauconite*, a mineral which is supposed to be formed at the present day, on moderately deep areas of the sea beds adjoining coast lines, by the action of decaying organic matter upon fine mineral particles derived chiefly from subaerial erosion.

2. The decomposition of this mineral, producing chiefly iron oxide and cryptocrystalline silica, and the concentration of these, together with the various phenomena consequent

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*Twentieth Ann. Rep., Minn. Geol. Survey, p. 136.

upon these operations, have produced all the various phases of the iron-bearing rock, including the ore-bodies.

3. During the process of concentration, in areas of comparatively free oxidation, iron replaces silica; in areas of extremely scant oxidation, silica replaces iron.

4. The great ore-deposits are believed to have formed in large areas of weakness, which have chiefly resulted from regional disturbances. The date of these disturbances, and of the beginning of the formation of some of the largest ore-deposits, is provisionally assigned to Keweenawan time.

THE COLUMBIAN EXPOSITION: NOTES ON VARIOUS EXHIBITS RELATIVE TO MINERALOGY AND PETROGRAPHY.

By George H. Williams, Baltimore, Md.

There was at the Exposition a considerable amount of material of especial interest to students of mineralogy and petrography, but this was for the most part so widely separated and distributed through so many different buildings as parts of varied and little related exhibits, that a patient and prolonged search was necessary to discover it. The following brief notes, which are the substance of information relative to these subjects communicated to the Madison meeting of the Geological Society of America, do not pretend to any completeness. They are merely jottings made in regard to apparatus and collections of mineralogical and petrographical importance, as these happened, one after another, to come under the writer's notice in various parts of the Exposition grounds.

I. Mineralogical Models and Apparatus.

One of the most noteworthy and novel, but at the same time probably one of the least noticed mineralogical exhibits was contained in a small case in the Russian pedagogical museum, in the central west gallery of the Manufactures building. It contained the kaleidoscopic mirrors for crystallographic demonstration, as suggested by Hess, and improved by Professor Federow of St. Petersburg (see Neues Jahrbuch für Mineralogie, etc., 1889, I, p. 54; ib. 1890, I, p. 234; and the writer's Elements of Crystallography, 3d edition, p. 196).

These mirrors consist of hollow triangular pyramids of definite angles, lined with looking-glass and held firmly by their apices in an inverted position by a universal joint, so that they can be inclined at any angle. If into such a pyramid some opaque liquid be poured its surface can be successively given any inclination to the three reflecting surfaces by altering the position of the mirror. The multiple reflection of this surface reproduces some form of that crystal class for which the particular mirror has been made, divided by all of its planes of symmetry, and this form may be made to pass by every intermediate stage, into any other form having the same grade of symmetry by suitably altering the inclination of the mirror. As a guide to the proper positions of the mirror, one of its edges may be prolonged as a needle to a gnomic projection of the forms desired and any one of these may then be produced by placing the point of the needle at the corresponding projection pole. One mirror may be made for each crystal class having a different grade of symmetry and all may fit into the same standard. They are, however, only of especial advantage for those of the higher grades of symmetry, like the holohedral and hemihedral divisions of the isometric, hexagonal, tetragonal systems. From practical experience the writer can say that it would be difficult to imagine a more beautiful or satisfactory piece of apparatus for the demonstration of the symmetry and relationships of crystal-forms than these mirrors.*

In the New South Wales exhibit in the same gallery, Prof. Liversidge of Sidney had two ingenious sets of crystallographic axes to illustrate the relationships of the pyramidal and prismatic forms in different systems. These were of brass and sufficiently large to be seen by a large class. Each was fixed to a solid standard, and by means of a movable rod inside of the exterior hollow one, each axis was extensible by rational increments. By a joint at the center these axes could also be given any inclination to one another, and, as their extremities were united by a white elastic cord, they admirably illustrated, as they were thrown from one position into another, the relations of a form in one crystal system to the corresponding form in any other.

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*Within the past few months the writer has had a set of these mirrors made by Chas. Willms, surgical instrument maker of No. 300 North Howard St., Baltimore, which has proved in all respects most satisfactory. The workmanship is admirable, and the instrument is one altogether fitted for class demonstration.

In the central west gallery of the Mining building, Dr. F. Krantz of Bonn had displayed a large assortment of his unrivalled crystal models, now too well known to require special mention. These are of glass and of two different sizes in wood, and for stability, accuracy and cheapness are unsurpassed.

Other less important exhibits of crystal models were made by Apel of Göttingen in the German University gallery of the Department of Liberal Arts, by the Russian pedagogical museum, and by Ward of Rochester.

Very important optical instruments relative to mineralogy were to be seen in the German University exhibit in Liberal Arts; in the German Association of mechanical and optical manufactures in the N. E. gallery of the Electrical building, and in the French educational exhibit. Here the well-known instruments of Fuess, Voigt and Hochgesang, Steeg and Reuter, Zeiss, Apel, Nachet and Werlein, were displayed and full descriptive catalogues given to all persons interested enough to ask for them. Most of this apparatus is already familiar to mineralogists, although there were not a few novelties, especially in the way of refractometers, goniometers, and microphotographic appliances.

Various pieces of optical apparatus for mineralogical purposes were also exhibited by others than manufacturers, as for instance, Mr. G. F. Kunz in the Mining building gallery, Harvard, Columbia, Johns Hopkins, and other universities in the Liberal Arts.

Microscopes especially designed for mineralogical and petrographical investigations were displayed in various widely separated exhibits. Those noticed and examined by the writer were by Fuess of Berlin (German University gallery), by Seibert of Munich (Krantz exhibit), by Voigt and Hochgesang of Göttingen (Electrical gallery), by Zeiss of Jena (same), by Leitz of Wetzlar (with Richards & Co., Mining gallery), by Nachet of Paris (French gallery), and Kunz (in Mining building), and by Bausch and Lomb of Rochester. English instruments by Swift and Beck were also in the English educational gallery.

Of all these microscopes those made by Fuess seemed on the whole to be most satisfactory, both as regards convenience, variety of appliance, workmanship and price.

II. Mineralogical Collections.

Among the wealth of mineral exhibits, most of which were naturally concentrated in the Mining building, it is of course possible here to specify in the briefest manner only the most noteworthy. On the other hand, the great systematic collections of minerals exhibited by English and Ward were so prominent and so attractive that no one at all interested in the subject of mineralogy could fail to have examined them. Hence they require no especial mention here, while no space at the disposal of this brief resumé could do justice to their ample treasures.

Among objects of especial scientific interest should be mentioned the collection of the rare calcite crystals from Rossie, N. Y., shown by the State Museum; the quartz crystals from Middleville, N. Y., shown by Mr. Crim; the galena, sphalerite and large calcite crystals in the Missouri pavilion; the topaz crystals from Japan; the crystallized gold from Breckenbridge, Colorado; silver crystals from Montana; azurite from Arizona; great yellow calcites from Wyoming; gold, diamond and emerald crystals from New South Wales; and argentite, calcite and fire opal from Mexico.

In a small mineral collection exhibited by Mr. Kidd of Kingston, Ontario, were two very remarkable crystals of black scapolite found at Eagle lake. They are of large size, perfectly terminated at both ends, and show both pyramid and prism of the third order in complete development.

More or less complete systematic collections of the minerals found within their borders were made by New York, Maine, Massachusetts, New Jersey, North Carolina, and various western states; by the New York Mineralogical Club, of the minerals of New York island; and by Mexico, Japan, Canada, and New South Wales.

The most remarkable collection of precious and semi-precious stones, both mounted, unmounted and in the rough, was exhibited by Tiffany & Co., of New York, partly in their main pavilion in the Manufactures building, and partly in the west gallery of the Mining building. This included examples of all native American gems and many unique foreign specimens, especially from Russia. In this connection the collections by Mr. Kunz to illustrate the association and geological mode of occurrence of diamond, opal, amber, platinum and pyrope deserve especial mention.

Among other noteworthy exhibits of gems, the great display of Kimberly diamonds and of the gangue rock from which they were being washed was, of course, pre-eminent. The output of the Jagersfonstein diamond mine for a single day (Feb. 12th, 1893), exhibited in the pavilion of the Orange Free State in the Agricultural building, contained 546 stones weighing 651 carats. Many of these were of fine color and purity, one of them weighing about 30 carats. This mine is said to have produced in May, 1893, the largest diamond known, weighing 971 carats. Rough diamonds were also shown from the fields of Bingera in New South Wales, and one from North Carolina.

Ceylon exhibited in her own building many characteristic gems, including ruby, sapphire, alexandrite, cymophane, pearls, spinel ruby, zircon, topaz, cinnamon garnet, and moonstone. The Russian manufactures exhibit likewise included many precious and ornamental stones found within the limits of the empire. Among these were crystals and cut specimens of aquamarine, alexandrite, blue topaz, chrysolite and phenacite; while among the ornamental and polished stones may be named jade, malachite, lapislazuli, rhodonite, jasper, selenite and labradorite. The latter mineral from a newly discovered locality in the department of Kiew, in southern Russia, surpasses all other labradorite in its iridescence.

North Carolina was especially noteworthy in her display of native gems, including ruby, sapphire, aquamarine, golden beryl, hiddenite, rose garnet, amethyst and rutilated quartz. Other gem exhibits which deserve mention embrace the fresh water (Unio) pearls from Wisconsin, the rubies and sapphires from Montana, the opal from Idaho, the turquoise from Villa Grove, Colorado, the asterated quartz, blue sodalite and chatoyant perthite from Canada, tourmalines from Maine, and various stones from Siam, Mexico, and New South Wales. The beautiful case of rough and cut gems so artistically displayed in English & Co's mineral collection also calls for special remark.

White mica for commercial purposes was exhibited by the Palermo Co., of Groton, N. H., and from the Ray mines in North Carolina, while the huge sheets and crystals of phlogopite (amber mica) from Canada, now in demand for electrical apparatus, was quite a novelty.

Cut and polished agates were shown by Krauth and Dreher, of Oberstein, where this industry is principally carried on, while the fine Bigelow collection of agates, accompanied by many thin sections, was displayed by Harvard University in the south gallery of Liberal Arts.

Meteorites were shown in great number and variety by Ward, of Rochester, by Harvard University, and by Mr. G. F. Kunz.

Scattered among the various state buildings were a few collections of some interest, while in others specimens of characteristic crystals were on sale. Thus good crystals of copper could be had in the Michigan building, orthoclase in the Colorado building, rubellite and serpentine in the California building, Sioux jasper, tin ore and rose quartz in the South Dakota building, etc.

The exhibit of minerals in the Government building was a selection from the well-known cases in the National Museum, and in its beauty, arrangement and educational value it came up to the high standard set by that institution.

In these notes no attempt has been made to take into consideration exhibits of ores, metals, coal, oil, clays, asbestos, or other minerals of purely commercial interest.

III. Petrographical Materials and Collections.

These may include abrasives, microscopic rock-sections, systematic collections, ornamental stones and building stones; but again, no attempt will be made to enumerate any exhibits which did not have a scientific bearing. To both abrasives and building stones a long report might easily be exclusively devoted, but they can here be mentioned only in so far as they bear on the theoretical aspects of petrography.

Of much importance to all interested in preparing sections of minerals or rocks is the recently discovered abrasive "carborundum," now manufactured and put on the market in all desired sizes by the Carborundum Company of Monongahela, Pa. This new substance is a beautifully crystallized carbide of silicon (C Si), accidentally discovered by Mr. E. G. Acheson while watching the action of an electrical furnace upon a mixture of charcoal and clay. It is now made in quantity by subjecting a mixture of coke and sand to a powerful electric current. The result is a mass of tabular hexagonal crystals of a greenish color, high luster and brilliancy, which possess a degree of hardness only inferior to the diamond. Careful tests by the writer and Mr. G. F. Kunz, showed that these crystals would readily scratch a polished sapphire, while a wheel composed largely of carborundum will cut rapidly into a mass of solid corundum. Practical tests have shown that aside from many uses in the arts, this substance is unrivalled for the preparation of rock-sections for microscopical study. The powders 160 and 220 accomplish the coarser grinding very rapidly, while the 6 and 10-minute powders (*i. e.* materials fine enough to remain in suspension 6 or 10 minutes) may be used to finish the grinding with unexampled ease and expedition.

Descriptions and photographs of machines for grinding and sawing rocks and minerals were exhibited in the Department of Liberal Arts by Prof. Dwight of Vassar College, and by the Johns Hopkins University.

A number of collections of thin sections of rocks and minerals, many of them showing good workmanship, was also scattered through the exhibition. Thus, in the German University exhibit were seen products of the well known firms of Fuess of Berlin, Krantz of Bonn, and Voigt & Hochgesang of Göttingen, while others of the same kind were placed in the German optical exhibit in the Electrical building. The admirable work of Ivan Werlein of Paris was shown in the French department of Liberal Arts and in the Harvard University (Bigelow) collection of agates. American work was exhibited by the N. Y. state Museum of Natural History at Albany, by Prof. Dwight of Poughkeepsie, and by Prof. Wolff of Harvard. It was also shown by the U. S. Geological Survey in the Government building. Richards & Co.'s exhibit in the gallery of the Mining building contained a considerable display of rock and mineral sections by Max Wasserschleben of Giessen, but perhaps the best exhibit of this kind to be found anywhere in the

Fair was that in the Swedish building by A. R. Anderssen, of Upsala. These sections were remarkable for their extreme thinness, perfect evenness, and in many cases for their great size. Some of the sections of the orbicular granites from Slattmossa and Kortfors showed a perfection of workmanship rarely equalled.

Systematic rock collections were exhibited by Ward and Krantz. A quite general collection was also shown by the U. S. Geological Survey, and more special ones by the state surveys of Minnesota, Missouri, New Jersey and North Carolina. Maine and Massachusetts, though without geological surveys, also displayed suites of their rocks. The government surveys of Canada, Japan and Sweden likewise showed extensive petrographical collections, accompanied by excellent catalogues. The New York Mineralogical Club showed a set of the rocks found on New York island.

Among exhibits of ornamental stones perhaps the most novel and noteworthy were those of the New Pedrara onyx from Lower California, and of the rose garnet rock from Xalostoc, Prov. of Morelos, Mexico. The latter, which is an aggregate of white wollastonite, yellow vesuvianite and rose colored grossular, seems to be the product of contact metamorphism in a limestone, analogous to the well known occurrences of the Fassa Thal and the Banat. It is now being studied by Dr. A. C. Gill.

Other notable decorative stones were the Arizona silicified trees and the Sioux jasper (quartzite) from South Dakota exhibited by the Drake Polishing Company. Ward also displayed a fine collection of 350 polished slabs of marbles, serpentines, and other decorative stones.

The great slabs of polished granite, porphyry and other ornamental stones from Elfdalen and other localities in Sweden, placed just outside the Swedish government building, well deserve mention, as well on account of their size as their beauty. A beautiful ornamental stone from Langesundfjord in Norway, displayed in the Manufactures building, seems destined to become popular on account of the fine iridescence of its feldspar. This rock is well known to geologists as Brögger's laurvikite.

Of the great number of building stone exhibits scattered through the grounds no account can be taken here.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Coal Deposits of Iowa. By CHARLES ROLLIN KEYES. Iowa Geological Survey, vol. II, 536 pp., 221 figures, 18 plates. Des Moines, 1894. This volume is uniform in size and style with the first number of the series already issued. It is printed on the same heavy paper, and the execution is exceptionally good. As is stated in the preface, this report does not attempt to cover all the various matters connected with the coal which a state survey may properly be expected to investigate. The detailed stratigraphy of the various coal seams must of necessity be the result of investigations extending over a considerable period of time: the determination of the best methods of mining and forms of mining machinery also forms a subject in itself; the studies on the properties of the Iowa coals and the determination of the most economic use of each require long and careful research; each of these subjects has been taken up, and in time the results may be expected. The present volume comprises 200 pages or more devoted to a consideration of the geology of the Mississippi basin with reference to its bearing on the Iowa Coal Measures. Succeeding this is an equal number of pages devoted to the details as exhibited in the various counties. The volume closes with a brief consideration of the coal industry. In the first part of the book a number of interesting faults are described; and the stratigraphy, classification, lithology and geological history of the Carboniferous, both Lower and Upper, are treated with a fullness of detail never before attempted in this field. The author has in this summarized the results of his work, not only in Iowa, but in neighboring states, and so throws considerable light upon the Carboniferous history of the whole Mississippi valley. The classification of the formations is unchanged, and the nomenclature is as used in the previous volume of the Survey.

In connection with the study of the stratigraphy of the Coal Measures are the elucidation of the nature of coal horizons and a harmonizing of the various theories which have been from time to time proposed. These are of considerable interest to both the geologist and the miner. As is well known, the earlier workers in the American coal fields held strongly to the idea of the parallelism of strata, and in accordance with that idea the individual coal seams were in many cases believed to be practically coëxtensive with the Coal Measures area. In recent years, however, detailed study has led rather to the other extreme, and the remarkable discontinuity of the coal seams has been emphasized. It has been shown time and again that, in this field at least, individual seams rarely have more than a very limited extent. Yet the fact remained that coal was more usually found at certain levels than at others. For example, nearly one-fourth of the total output of the state comes from within fifty feet of the base of the Coal Measures. These and numerous other apparently opposing facts are happily reconciled by the explanation of the real character of coal horizons: that stretching out through the Coal Measures there are certain definite stratigraphic horizons along which bituminous matter was deposited abundantly, making a certain set of conditions prevalent over a considerable area. The distribution of the coal was, however, dependent entirely upon the local conditions, which determined whether at any point a single thick seam, several thin seams, bituminous shales or even non-bituminous matter, should be deposited. This throws considerable light on the real conditions existing at the time of the local formation, and has also a very direct value to the prospector as guiding him in his search.

In connection with the report is a geological map of the state, which shows noteworthy 'advance over that published the previous year. There is more detail in tracing formation boundaries: the eastern border of the Coal Measures is more sharply defined; and the Cretaceous is made to extend over a considerable stretch of new territory in the southwest.

A short chapter is given on the origin of coal. The various theories advanced are summarized, and the knowledge up to date is given. A chapter on the composition of Iowa coals contains notes on their physical properties and the results of nearly 150 chemical analyses. The question of waste in coal mining is briefly touched, and the various methods of utilizing fine coal are discussed. The extent and growth of the industry in Iowa is shown by various tables and maps so arranged as to bring to the eye at once a considerable mass of information: and the rapid growth of the industry, as stated by these tables, makes a good showing for the state. H. F. B.

Revolution in the Topography of the Pacific Coast since the Auriferous Gravel period. By J. S. DILLER. Journal of Geology, vol. II, pp. 32-54, Jan.-Feb., 1894. During the Pliocene and Pleistocene periods, according to the studies of Mr. Diller, Prof. Le Conte, Mr. W. Lindgren, and others, the region of the Sierra Nevada, which previously had been reduced by erosion to a low altitude, approaching a baselevel, has undergone very great, but gradual orogenic changes, with extensive outpouring of lavas. The northern end of the Sierra has been raised "at least 4,000 feet, and possibly as much as 7,000 feet," while a fault of more than 3,000 feet has been developed along the eastern face of this highest and grandest mountain range in the United States. The approximately baselevelled old plain now forms the long western slope, which, descending gently to the Sacramento and San Joaquin valley, has become deeply furrowed with cañons by the rejuvenated streams. The auriferous river gravels, varying from 50 to 500 feet in thickness, were mostly deposited during the initial part of this revolution: and the source of their material was the thick deposits of residuary detritus which had accumulated upon the surface of the land during the baselevel period.

Elementary Meteorology. By WILLIAM MORRIS DAVIS, Professor of Physical Geography in Harvard College. 8vo, pp. xii, 355, with six plates (charts of the world, showing isotherms and isobars), and 106 figures in the text. Boston: Ginn & Co., 1894. This very thorough, well arranged and clearly presented treatise on the growing science of meteorology is written with reference both to use in the class-room and for general readers. It contains the recent important additions to the theoretic explanations of the atmospheric circulation and production of storms which were studied out by the late Prof. William Ferrel, of Washington; and the author also acknowledges his great indebtedness to *Klimatologie* and other writings by Prof. Julius Hann, of Vienna. Looking over the admirable work which Prof. Davis has done in this volume and his many geological papers, especially those relating to the glacial drift, we cannot refrain from earnestly hoping that he may next combine these investigations in treating of the climates of the Ice age and earlier geologic ages.

Crinoidea of Gotland. By F. A. BATHER. Kongl. Svenska Vetenskaps-Akademiens Handlingar. Band 25, No. 2, 200 pp., 10 plates. Stockholm, 1893. Paleontologists have long admired the crinoids found in the Silurian rocks of Gotland; but ever since the publication of Angelin's beautiful "Iconographia Crinoideorum," some fifteen years ago, the Swedish fossils have greatly puzzled students of crinoid morphology. The marvelous structures and curious combinations pictured in the Iconographia disclosed difficulties which were insuperable to the anatomist. Although the figures are so artistic and so perfect as to cause a suspicion to linger in one's mind that many may be to some extent restorations, it was with considerable astonishment that workers in general learned recently that many of Angelin's illustrations were mere combinations and composites, in some cases made up of several individuals and in other instances of even different species.

The chief purpose of Mr. Bather's timely paper is to discuss the Gotland crinoids in the light of recent morphological progress and to set aright many of the erroneous ideas promulgated by the Swedish author. This has been all the more important on account of the close relations existing between the Silurian crinoidal fauna of England and that of Sweden. It was upon British fossil crinoids that Mr. Bather first began to study, but it was soon found necessary to take up the related, and in part identical, species from the continent before working up the home collections.

The portion of the work just issued is Part I, the Crinoidea Inadunata. These are taken up first, because, as the author says, they may be very plausibly regarded as the simplest forms of crinoids and as least removed from the type whence all families of crinoids have sprung.

In Gotland the Inadunata are represented by at least forty species, which are described in the paper, and probably by a few other species still doubtful, which have been set aside for the present in the hope of better material coming to light. Of the forty species considered, eighteen were founded by Angelin, sixteen are regarded as new, and the rest were previously described by other authors. These species are referred to ten genera, of which Gothocrinus is regarded as new, and one, Homocrinus, has not been hitherto recorded from Europe. These genera are distributed among several families. A full list of the species is given with their stratigraphical horizons. The forms are all described with great minuteness and are finely figured, not only as to general physiognomy, but especially as regards anatomical structure. An interesting fact in respect to the geographical distribution of the species is that the forms which are among the commonest in England are the rarest in Gotland, and *vice versa.* Similar peculiarities in the range of many of the Carboniferous forms had already been known among the American crinoids.

The facts brought out by the careful review of the Swedish material will change very considerably many opinions now held in regard to certain structural features of the stalked echinoderms. A consideration of Pisocrinus compels a complete change in the orientation of the calyx, and enables this genus to be compared for the first time with other Monocyclica. Another point of great interest is the foundation on a scientific basis of the nomenclature of the skeletal parts in the Calceocrinidæ, a group which has long remained a morphological anomaly. A more rational classification than has heretofore been suggested has been prepared for the Inadunata in the establishment of two great subgroups based upon the presence or absence of infrabasals. These are the Monocyclica and Dicyclica.

Taken as a whole, the "Crinoidea of Gotland" may be regarded as one of the most valuable paleontological contributions which has appeared for a long time. It indicates clearly one of the most fruitful lines along which this branch of science is progressing, and presents a marked contrast to most of the papers passing under the name of paleontological publications.

Descriptions of Some New Species of Invertebrates from the Paleozoic Rocks of Illinois and adjacent States. By S. A. MILLER and WM. F. E. GURLEY. (Bulletin No. 3, Illinois State Museum of Natural History, 81 pp., Springfield, 1894.) Under the auspices of the State of Illinois, Messrs. Miller and Gurley describe as new some sixty fossils, chiefly from the Carboniferous terranes of the Mississippi basin. From the very indifferent diagnoses of the species it would be almost impossible to recognize many of them, but with the figures it is easily seen that no less than three-fourths of the so-called "new species" have already been fully described, while nearly a dozen of the "types" are manifestly too imperfect to deserve recognition. There appear consequently only two or three valid species out of the three-score noted. Most of the descriptions are of crinoids, and some of these, although here regarded as new, were well described and figured more than a third of a century ago, including species which are widely known to all persons familiar with the paleontology of the upper Mississippi valley.

This Bulletin gives the fifth batch of "new species" which the senior author has issued during the past two or three years. Altogether there have been proposed in the series several hundred "new" generic and specific titles to which this author has appended his name. Chiefly to contain them, the same author has found it necessary to issue a special addition to his catalogue of American Paleozoic fossils. In the five pages mentioned it is safe to say that no less than four-fifths of the species described as "new" must be relegated to the limbo of synomyms.

The illustrations accompanying the "descriptions" are in most cases woefully inaccurate as regards the structural features of the objects represented, or rather misrepresented. Several are so poorly depicted that it would be an utter impossibility for even the most expert to tell the order to which they should be referred.

It is to be hoped that under the new régime the Illinois State Museum of Natural History will turn its efforts in a more fruitful direction.

A new sub-order of the Ancylopoda. By HENRY FAIRFIELD OSBORN. (Trans. N. Y. Acad. Sci., vol. XII, p. 95.) The foot of *Artionyx* is distinguished from that of *Chalicotherium* by the character of ankle and pes, which present a marked resemblance to the Artiodactyla, while *Chalicotherium* represents these structures as found in the Perissodactyla. Both genera are ungulate in ankle joint, but the phalanges terminate in claws. In view of the double parallelism between these two forms and the two subdivisions of the ungulates, it is suggested to divide the Ancylopoda into the Artionychia and Perissonychia.

The Evolution of Teeth in Mammalia in its bearing upon the Problem of Phylogeny. By HENRY FAIRFIELD OSBORN. (Trans. N. Y. Acad. Sci., vol. XII, p. 187.) The following abstract of Dr. Osborn's paper is given. He reviews the recent researches and theories of Kükenthal, Röse and Tacker, upon the formation and succession of the dental series in mammalia, and points out that especially in marsupials, cetaceans and edentates (with other placentates), the existence of two series of teeth is now abundantly proven, as well as the fact that *homodont* forms were derived from early *heterodont*. Recent discoveries indicate that in marsupials teeth of the second series might be interposed in the first series; thus explaining the typical dentition of such genera as *Didelphis*. This transposition permits a comparison of the dentition of marsupials with that of Jurassic mammalia $\left(\mathrm{i}\ \frac{4}{4},\ \mathrm{c}\ \frac{1}{1},\ \mathrm{p}\ \frac{4}{4},\ \mathrm{m}\ \frac{3}{3}\right)$.

It is further noted that the triconodont type (as *Amphilestes*) may be regarded as the hypothetical point of divergence of placental mammalia. As to the form of teeth crowns, the theory (Kükenthal, Röse) that the complex mammalian types were made by concrescence of simple reptilian cusps, is, upon the evidence of the Jurassic mammalia, shown untenable,—as well as the converse theory that cetaceans have derived homodynamous forms by the splitting of the cusps of the triconodonts.

Contributions to the Anatomy of Dinichthys. By BASHFORD DEAN, Ph. D. (Trans. N. Y. Acad. Sci., vol. XII, pp. 187, 188.) In this paper the author has "correlated the parts of this Devonian- Lower Carboniferous arthrodiran with those of *Coccosteus*. Notes are made on the disposition and characters of the lateral line of organs, pineal foramen, nasal capsules, dentary plates, ginglymoid articulation of lateral shoulder plates, characters of shagreen, and probable disposition of paired and unpaired fins.”

The La Plata Museum. By R. LYDEKKER, B. A., F. Z. S. In *Natural Science* (vol. IV, Nos. 23, 24) Mr. Lydekker gives an interesting account of this Museum, so rich in fossil vertebrates. He describes many of the best examples from the Pampean, Patagonian, and other deposits. He finds that very many of the new genera (named by certain South American paleontologists) are but species of previously described genera, or are the same genera with different names. The author well describes this surprising confusion when he says: “Indeed, on the principle (or rather, want of principle) which appears to have guided the Argentine paleontologists, about a dozen species and some half a dozen genera might easily be made out of the remains of the common horse.” This statement is the outcome of his examination of some of the forms with different generic names in which the dentition had assumed different forms according to the age of the individual in question, and he adds, “which even any ordinary student would say were identical.” After reading Mr. Lydekker's account of the wonderful treasures in this museum, one regrets that these fossils are not more accessible; for, with what has been remarked above, it is almost unnecessary to say that these descriptions by South American workers are not strictly reliable.

The Mean Density of the Earth, an essay to which the Adams prize was adjudged in 1893 in the University of Cambridge. By J. H. POYNTING. 8vo, pp. xx, 156, with illustrations and seven folding plates. (London, Chas. Griffin & Co., 1894.) In this work we find a historical account of the various attempts to determine the mean density of the earth from the time of Newton to the present. “It is not a little remarkable that Newton hit upon the limits between which the values found by subsequent researches have nearly all lain.” The author describes some experiments of his own, made with the common balance, in which he obtained the figure 5.493 as the earth's average density. The observations and mathematical calculations are given with considerable detail, and the various factors of the problem are elaborated fully. The average of the fourteen different determinations that have been completed by different calculators gives the figure 5.523. The work shows great care in preparation, and furnishes a complete résumé of the subject, thus constituting a valuable work for reference. H. V. W.

On the chemical composition of chondrodite, humite and clinohumite. By S. L. PENFIELD and W. T. H. HOWE. Amer. Jour. Sci., vol. 47, pp. 188-206, March, 1894. By a series of careful analyses and a comparison with other analyses the authors show that these three minerals are *not* identical in chemical composition. The formulæ established are:

Chondrodite	$Mg_3\,[Mg\,(F.\,OH)]_2\,[SiO_4]_2$
Humite	$Mg_5\,[Mg\,(F.\,OH)]_2\,[SiO_4]_3$
Clinohumite	$Mg_7\,[Mg\,(F.\,OH)]_2\,[SiO_4]_4$

They thus are seen to form a series which varies progressively from chondrodite to clinohumite by an increase of one molecule of Mg_2SiO_4. The variation in composition is found to be intimately connected with the crystallization, the length of the vertical axis increasing from chondrodite to clinohumite. G.

On the crystallization of enargite. By L. V. PIRSSON. Amer. Jour. Sci., vol. 47, pp. 212-215, March, 1894. Quite a number of measurements of enargite ($Cu_3 AsS_4$) crystals from Colorado are given, also several figures of this species which has been rarely figured in its former descriptions. Three new forms were observed. G.

Relations of the Lower Menominee and Lower Marquette series in Michigan. By HENRY LLOYD SMYTH. Amer. Jour. Sci., vol. 47, pp. 216-223, March, 1894. These two series have been supposed to be equivalent, in a general sense, by nearly all the geologists who have worked in this region. The author is able to modify this conclusion somewhat and to give it more definite shape. The divisions are:

Menominee.	*Marquette.*	
Michigamme jasper.	Jasper banded with ore.	Iron formation.
Slates (principal iron formation).	Magnetite-actinolite schist.	
Limestone.	Quartzyte.	
Quartzyte.		

The author's preliminary conclusions, based largely on the equivalence (partly assumed) of three lines of magnetic attraction, are as follows: 1. The lower Menominee quartzyte, limestone and slates are all older than any formation in the Marquette area. 2. The Michigamme jasper was deposited in a continuous sheet over both districts, and in the Marquette constitutes both the iron-bearing formation and, for the most of the area, the lower quartzyte. 3. The principal ore horizon of the Menominee has no equivalent in the Marquette district. G.

On the sequence of perlitic and spherulitic structures; a rejoinder to criticism. By FRANK RUTLEY. Quart. Jour. Geol. Soc., vol. 50, pp. 10-14, 1 plate, 1894. The author replies to a criticism, of Messrs. Harker and Marr, of his statement that in a perlitic felsite from Long Sleddale valley, Westmoreland, spherulitic devitrification followed the development of the perlitic structure. Figures are given to show this point, both in the rock from Long Sleddale and in an obsidian from Meissen. Mr. Rutley sees no reason to alter his conclusion that sometimes the spherulitic structure is later than the perlitic. G.

Sulfoborit, ein neues krystallisirtes Borat von Westeregeln. By H. BUCKING. Mathematische u. naturwissenschaftliche Mittheilungen aus den Sitzungsb. d. k. preussischen Akad. d. Wissenschaften zu Berlin, Heft IX, Nov. 1893. Some determinations of the properties of this new mineral show that it is orthorhombic with an axial ratio of $a : b : c = 0.6196 : 1 : 0.8100$. Five forms are described and five rather distinct habits were found. A good cleavage occurs parallel to the unit pyramid, and a poorer one parallel to the base. The specific gravity is from 2.38 to 2.45. The plane of the optic axes is the brachipinacoid. The double refraction is negative. The chemical composition is $3MgSO_4 . 2Mg_3B_4O_9$.

$12H_2O$. Sulfoborite is the first representative of a new group of natural compounds of borates and sulphates, which has an analogue in lüneburgite, a hydrous compound of magnesium borate with phosphate of magnesium. G.

CORRESPONDENCE.

Discovery of Diceratherium, the two-horned Rhinoceros, in the White River beds of South Dakota. Several years ago Prof. Marsh described under the generic name of Diceratherium a two-horned Rhinoceros from the John Day beds of Oregon. Naturally we should expect to find the ancestor of the John Day form in the White River beds; but up to the present it has not been reported. The Princeton Scientific Expedition of 1894 has been fortunate in securing three skulls which at present are not distinguishable generically from Diceratherium. One of these skulls has been freed from the matrix and it presents characters which at once distinguish it from any of the John Day species yet described. It may be called Diceratherium proavitum in reference to its relation to the John Day forms.

The type specimen consists of a nearly complete skull without the lower jaws. The principal specific characters are as follows: Skull long and low, broad especially in the frontal region; superior surface slightly concave anteroposteriorly; no well defined sagittal crest; strong postorbital processes. Nasals strong but not coössified. About one-third the distance from their extremities to their junction with the frontals are developed upon their upper and outer edge a pair of rugose prominences resembling very much in appearance the rugosities supporting the nasal horns of the recent rhinoceroses; they doubtless served the same purpose in Diceratherium. Just behind this pair of rugosities the nasals are constricted, but posteriorly they expand again to meet the broad anterior border of the frontals. In front of the pair of rugose elevations which supported the horns the nasals narrow rapidly and are directed downward and forward. The occipital crest is deeply emarginate and overhangs the occipital condyles. The zygomatic arches are rather slender. The post-tympanic and post-glenoid processes are in contact but not coössified. The anterior opening of the posterior nares is situated just behind the posterior border of the molar one. Of the teeth only the molars and premolars are preserved in the type specimen; they are of moderate size. The premolar one is a strong, well developed tooth; the other teeth gradually increase in size from before backward. The dorsum is very flat with no suggestion of a median costa. There is a basal ridge on the dorsum of the true molars, but not on the premolars. The median sinus is shallow, especially in the premolars and molar one; it is obstructed by only faint rudiments of the crochet and anticrochet. The anterior and posterior valla are shallow. There is a cingulum on the inner border of the premolars only.

The remains of Diceratherium so far found in the White River are from the upper Oreodon beds (Protoceras beds of Wortman). The discovery of Diceratherium in these beds may be regarded as additional evidence in favor of Wortman's opinion that the top of the White River is the equivalent of the base of the John Day.

J. B. HATCHER.

ECONOMIC GEOLOGY OF THE UNITED STATES: REPLY TO DR. PENROSE'S REVIEW. It is not a very dignified proceeding for an author to reply to a review of one of his own works; but there are times when dignity must be sacrificed in order to place the truth before the public. It seems to me that one of these occasions has been created by Prof. Penrose's review of my Economic Geology of the United States which appeared in the February-March number of the Journal of Geology. This review, which occupies six pages of the magazine, finds the book wholly bad, and so inaccurate that not a word of praise can be found except for the "publisher's work," the "good language," and "the general scheme in the arrangement of the subject matter," which he says is "logical."

At first sight, the volume and virulence of the attack led me to infer that many vital errors had been found; the reviewer says that these "are only a few of the many that might be mentioned," like the school boy who found the things he was writing about "too numerous to mention." But, upon rereading it and boiling it down to the actual errors, these are found to be very few, and hardly sufficient in number to utterly condemn the work. On still further examining these the astonishing fact is revealed that all but two and possibly three, are errors of the reviewer! The purpose of this reply is to point out these errors.

As if to crush me at the very start, Prof. Penrose devotes an entire page to a discussion of my use of the term "ore," the implied conclusion of which is that the author of an Economic Geology does not know what an ore is. He quotes my definition and remarks that it should have been qualified. Forthwith he gives, among others, the very qualification (biotite) which I do give just five lines below the sentence quoted. He tells us that many ores are common rocks; but the Century Dictionary, in its definition of ore, written by a well known geologist, says: "A mixture of a native metal with rock or vein-stone is not usually called ore." The rock is gangue. "The term 'ore,'" he says, "has no scientific significance whatever," in refutation of my statement that it has. Had Dr. Penrose studied petrography he would probably not need to be told that the term ore, as I used it, is to be found in Rosenbusch's publications, and, in English, in Teall's British Petrography, p. 52. Thus one page of criticism, and the one upon which most energy is devoted, depends rather upon the reviewer's misconceptions than upon the author's inaccuracies. On the next page there is a very curious criticism and one that is extraordinarily unfair. He takes me to task for *not* saying just what I *do* say: as is shown by his own quotation from my book. I say that the silicates are of *little* importance as ores, and he quotes this. Three sentences below the one quoted I state that there are a few ores belonging to this group; but, notwithstanding this, he says that I have "evidently overlooked" certain silicate ores, which, however, are all described in their proper place in my book,—calamine on pages 23 and 243; garnierite on pages 292 and 294; and chrysocolla on pages 22 and 208.

Next, quoting me as follows: "Sometimes, though not commonly, gold occurs in iron pyrites in invisible grains," he says, "it is almost unnecessary to say that one of the most common modes of occurrence of gold is in intimate association with iron pyrites, so that this statement is extremely misleading." Not so misleading, I venture to say, as his criticism. On page 169, when speaking of gold, I say just what he does, but, although there is nothing in the quotation nor in his remark to indicate it, the sentence quoted by him was from a paragraph on *iron pyrite.* The common occurrence of gold is in pyrite; but is gold common in pyrite?

His criticism of my statement that native gold is the "typical occurrence and the one from which the gold in use is obtained" is a criticism on my "good language." I had just spoken of the telluride as an ore, and it is evident that I meant the gold *as a whole*, not *all* of the gold.

His objection to my speaking of chalcopyrite as a combination of iron and copper sulphides in varying proportions, and of siderite as a similar combination of iron carbonate (the latter word being omitted by mistake) and calcite, depends upon his misinterpretation of the meaning of the word combination, which he assumes to mean *chemical* combination. That I recognize the fact that the mineralogical chalcopyrite and siderite are definite chemical compounds is shown by the fact that I gave their formulæ. Since I was not writing a text-book on mineralogy I did not feel called upon to introduce and explain isomorphous mixtures and replacements.

Excepting by hazarding a guess, Dr. Penrose does not appear to be able to understand what I mean by "mineralized ores." My meaning is explained on pages 15 and 16 of the book. Nor is it quite clear to him what I mean by "rust." Rust is oxidation and iron rust is the product of oxidation of iron, while lead rust is the similar product for lead. The pale yellow rust of lead, to which I refer and which he questions, is used by the prospectors of the west, or at least by some with whom I have been in the field in Montana, as a sign of lead.

The reviewer cannot understand on "what basis" an author has "modified" the geological sections of other authors. In the instance under consideration, as in others (and always with a statement of it), the sections were modified for the purpose of rendering them more diagrammatic, so that the beginner could understand them. The modifications were made for exactly the same reason that their technical descriptions were modified.

We are told that the book "bears evidence of a lack of the sense of proportion in the amount of space given to different subjects." It would have been more modest to have said that this seemed so to the reviewer.

One more misstatement should be mentioned. Prof. Penrose says that the book relates "mostly to the ore deposits of this country." Exclusive of the index and appendix, there are 456 pages in the book, only 190 of which are devoted to ore deposits, including the portions on foreign ore deposits. About half of the book is devoted to ores, if we include those preliminary chapters relating to ores and mining methods.

There are errors in the book—few text books are free from them; but only two of those pointed out by Prof. Penrose are errors of mine, and these two are blunders which, though inexcusable, are not at all vital. I welcome fair criticism and am glad to know of any errors in order that they may be corrected in possible future editions; but, entirely aside from my delicate position as author of the book in question, I emphatically object to a review like the one in question. The reason for it is not thoroughly apparent. I should hesitate to ascribe it to malice, and certainly will not retaliate by referring it to "an extremely superficial knowledge of economic geology." The only other cause that I can find for its inaccuracies is a hasty and superficial examination of the book, begun, perhaps, with the preconceived opinion that the book was worthless. The evident eagerness and the occasional violence of denunciation may, perhaps, have grown with the fancied discovery of errors.
RALPH S. TARR.

Ithaca, New York, April 11, 1894.

EARLY MAN IN MINNESOTA. The Archæologist for March, 1894, presents a paper on this subject by Prof. W. H. Holmes, which he had previously published in the AMERICAN GEOLOGIST for April, 1893; but no mention is made of this magazine, nor of the previous publication of the paper. In this republication, Prof. Holmes inserts a new sentence, saying that I "have been misled by the unverified statements of an inexperienced observer into constructing a section, repeated by Prof. Wright, in which an implement-bearing bed is carried entirely across the immediate valley of the Mississippi at the base of the glacial deposits." The section referred to,* however, shows the "stratum containing quartz chippings" (not implements in a finished state) as restricted to the locality of Miss Babbitt's examination on the east side of the Mississippi river close above Little Falls, though the section itself is extended across the valley to show the relation of this place and its drift with the river and the land surface on both its sides. This stratum, furthermore, is not "at the base of the glacial deposits." An undetermined thickness of till is shown below the modified drift, and the quartz-bearing layer is wholly above the till and *in* the basal part of this modified drift, as was observed by Miss Babbitt.

Having again attentively read her statements† of the condition of this most plentifully quartz-bearing bed of the modified drift at Little Falls, with its occasional grouping of numerous quartz fragments of similar forms, or of like lithologic character, apart in small hoards or places of assortment, I still believe that men making stone implements were here while the modified drift was being deposited. Nor was this geologically long ago, for Prof. N. H. Winchell's well known studies of the recession of the Falls of St. Anthony from Ft. Snelling to Minneapolis indicate that the time since the departure of the ice-sheet from Minnesota has been probably between 6,000 and 9,000 years, his average from three estimates being 7,800 years.*

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*First published in a paper in the Proceedings of the Boston Society of Natural History, vol. XXIII, pp. 436-447. Dec. 21, 1887; mostly reprinted in Wright's "Ice Age in North America," 1889, pp. 538-550.

†Proc. A. A. A. S., vol. XXXII, for 1883, pp. 385-390. Am. Naturalist, vol. XVIII, pp. 594-605, 697-708, June and July, 1884.

Professor Holmes suggests that tornadoes and overturned trees uprooting the ground to depths of several feet can account for the frequent occurrence of flaked quartz fragments in the superficial part of the modified drift in the vicinity of Little Falls, where they had been found by Prof. Winchell previous to Miss Babbitt's discoveries. If we consider the infrequency of the passing of tornadoes over any one place and the scarcity of the quartz chippings upon and in the surface soil, I think that this hypothesis seems improbable.

There is no inherent presumption against the presence of men at this locality when the ice-sheet was being rapidly melted away by a temperate climate. On the shores of the glacial lakes Agassiz and Iroquois, in and beneath their beach ridges of gravel and sand, Tyrrell and Gilbert have reported reliable evidences of man's presence, and these belong to the same time of final melting of the ice-sheet. Likewise the somewhat earlier stone implements found in glacial gravels in Ohio and New Jersey, and those of the auriferous gravels under lava flows which now are the cap of "table mountains" in California, all represent probably nearly the same late portion of the Pleistocene period.

Seeing the widely differentiated condition of the many tribes and larger divisions of the American race, some attaining much skill in arts and government, as in Mexico, Central America, and Peru, before the advent of Columbus and the conquering Spaniards, I cannot doubt that the first coming of men to this continent was previous to the geologically short and recent Ice age. Following Flower and Lydekker in regarding the American as a branch of the great Mongolian stock, we have in the general uplift of northern lands preceding and finally inaugurating the Ice age an easy route of immigration from Asia across a broad land area that has been since covered by the shallow Bering sea. No less time, probably, than the duration of the Glacial and Postglacial periods could suffice for the variations in physical types and in languages that have come about since the earliest migration of men to America.

In my recent paper in the Bulletin of the Geological Society of America (vol. V, p. 99, Jan., 1894), the duration of the preglacial time of increased elevation of northern lands is estimated as some 60,000 to 120,000 years; of the Glacial period, attending the culmination of the uplift, but terminating after the subsidence of the glaciated region, 20,000 to 30,000 years; and of the Postglacial or Recent period, extending to the present time, 6,000 to 10,000 years. WARREN UPHAM.

March 31, 1894.

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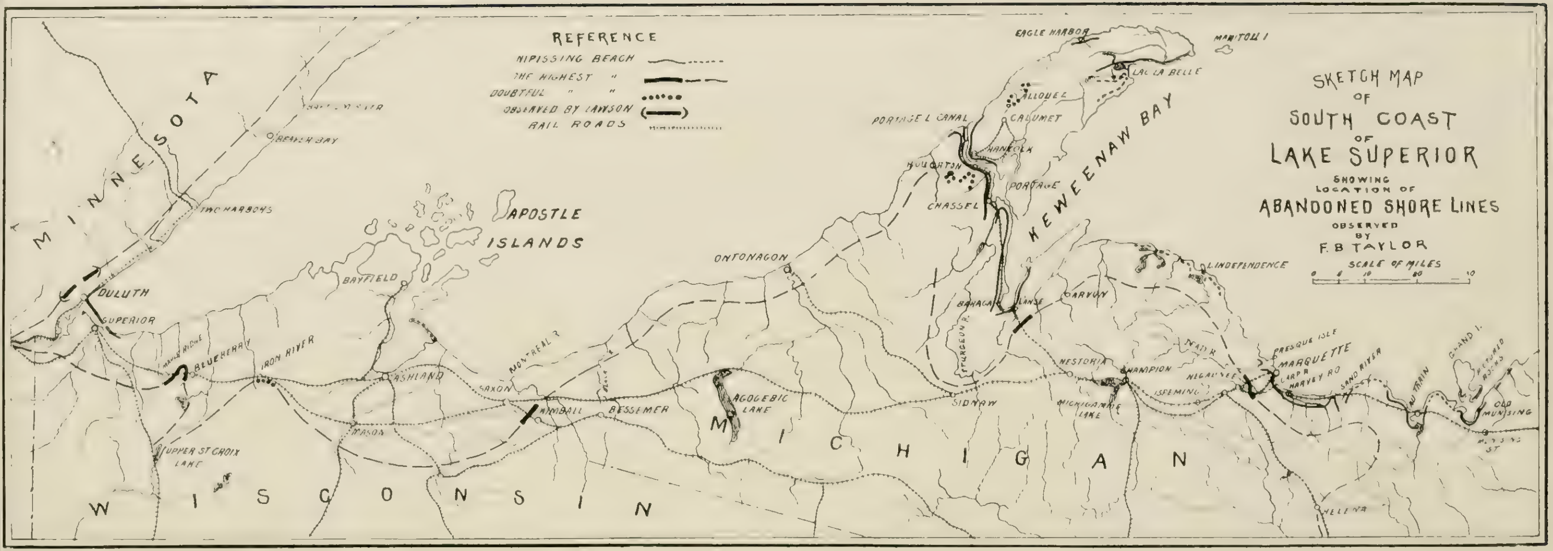
*Geology of Minnesota, Final Report, vol. II, 1888, pp. 313-341, with maps and plates.


SKETCH MAP
OF
SOUTH COAST
OF
LAKE SUPERIOR
SHOWING
LOCATION OF
ABANDONED SHORE LINES
OBSERVED
BY
F. B TAYLOR
SCALE OF MILES
0
5
10
20
30
REFERENCE
NIPISSING BEACH
THE HIGHEST "
DOUBTFUL " "
OBSERVED BY LAWSON
RAIL ROADS
MINNESOTA
WISCONSIN
MICHIGAN
BEAVER BAY
TWO HARBORS
DULUTH
SUPERIOR
BLUEBERRY
IRON RIVER
UPPER ST CROIX LAKE
BAYFIELD
APOSTLE ISLANDS
ASHLAND
MASON
SAXON
MONTREAL R
KIMBALL
BESSEMER
AGOGEBIC LAKE
ONTONAGON
PORTAGE L CANAL
HOUGHTON
HANCOCK
CALUMET
ALLOUEZ
EAGLE HARBOR
LAC LA BELLE
MANITOU I
PORTAGE
CHASSEL
KEWEENAW BAY
BARAGA
L'ANSE
ARVON
STURGEON R
SIDNAW
NESTORIA
CHAMPION
MICHIGAMME LAKE
L INDEPENDENCE
NEGAUNEE
ISHPEMING
PRESQUE ISLE
MARQUETTE
CARP R
HARVEY RD
SAND RIVER
AU TRAIN
GRAND I.
PICTURED ROCKS
OLD MUNISING
HELENA

THE

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A RECONNAISSANCE OF THE ABANDONED SHORE LINES OF THE SOUTH COAST OF LAKE SUPERIOR.

By F. B. Taylor, Fort Wayne, Ind.

(Plate IX.)

The places described in this paper were visited during July and September of 1893. With the exception of the localities at Sault Ste. Marie and those between Duluth and the Portage lake canal, I was accompanied throughout by Dr. Pearce. As in the exploration of other regions, including that of Green bay described in the preceding number of the Am. Geologist, the particular object of these excursions was to locate, if possible, the highest shore line of postglacial submergence. Although this object was held distinctly in view, our first trip was not successful in this particular. The highest shore line was not recognized at that time, although it was found later that it had been crossed twice.

Besides other fragmentary shore lines at intermediate levels, two very strongly developed beaches were found along this coast, which mark the most important epochs of its recent history. One of these is at a low level, not more than fifty feet above the present level of the lake at any point observed. The other, which marks the upper limit of postglacial submergence, is at a somewhat higher level than was anticipated, ranging between 535 and 590 feet above lake Superior. The lower of these beaches is so favorably situated for observation that it was traced continuously for many miles, but the upper one is in a rough and heavily timbered country and was seen only in a few places. The development of the latter, however, is so strong and so much care was taken to make sure of its identity in each place as the upper limit of submergence that its continuity between the points of observation is hardly to be doubted.

The character of the work described in this paper will not compare favorably in point of accuracy of measurement with the recent admirable work of Prof. A. C. Lawson on the north coast of this lake.* Our observations were all made by aneroid, but all of them are based either on a railroad station or the lake level near by, and as much care as possible was taken to determine and eliminate the weather variation.

THE NIPISSING BEACH.

Marquette to the Pictured Rocks. The lower of the two beaches is very strongly developed all along the south shore of lake Superior so far as seen. No beach, except the one which marks the maximum of submergence, has anything like its strength, and even that lacks its sharpness and definiteness of development. The reason for calling it the Nipissing beach will be pointed out presently. At Marquette this beach is about twenty-five feet above lake Superior, and for more than three miles southeast of the city it has the form of a flat, narrow cut terrace, which is occupied by the D., S. S. & A. railway and the lake shore drive. Near the city it abuts against the base of an immense drift bluff, which rises more than a hundred feet above it. The surface of this higher terrace is quite uneven, but its front is a sharp bluff made by the waves of the Nipissing episode. Farther east this shore line is represented by great, sandy beach ridges which have been built across the mouths of the valleys of the Chocolay, Sand and Au Train rivers. Each of these valleys was formerly a bay of the lake, but they have been almost entirely filled in by the sandy beaches of the Nipissing stage.

These beaches are finely developed in parallel lines at Harvey P. O., and from a point about half a mile west of this place the railroad is built upon them, and lies nearly parallel with them for about fifteen miles, to a point one mile east of

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*"Sketch of the Coastal Topography of the North Side of Lake Superior, with special reference to the Abandoned Strands of Lake Warren." By Andrew C. Lawson. Twentieth Annual Report, Minn. Geol. and Nat. Hist. Survey.

Sand River station. The belt of beaches varies in width from an eighth of a mile at Harvey to more than a mile at Sand River station. The Chocolay river flows westward behind them, close to the lake, for a distance of about four miles, that part of its course evidently being determined by the westward predominance of shore drift. In the case of the Au Train river the bay reached so far inland that the waves failed to carry the sand up to its head, but built out spits which united across it, and the waves afterward built upwards of forty distinct beach ridges of sand, arranged in successive order from Au Train lake, which was cut off in this way, out to the present shore. It is more than a mile and a half across these beaches. The process is still going on, as may be seen at the mouth of the Au Train river. I had visited the Au Train country in the autumn of 1882. In the eleven years which had passed since then, I could see that there had been a distinct growth of the shore line outward. At the sides of the outer ends of these valleys the shore line is plainly marked as a terrace cut into the drift. Lake Independence, Pine lake, and others along this shore, have the same origin as Au Train lake. At Old Munising, near Grand island, this beach appears again as a very sharply defined terrace of coarse white sand, about 200 yards wide and 25 feet above the lake. Fragments of it were seen still farther along the shore in clefts of the Pictured Rocks where small streams enter. Eastward the shore was not seen, but it is well known to be very sandy, as would be expected if it is bordered by the Nipissing beach.

Beginning at Light House point in Marquette, this same shore line passes through the northern part of the city and is finely developed in that locality. It is there composed of a series of sandy gravel, shingle ridges, the highest passing along the foot of a low bluff from which it is separated by a lagoon hollow. From Hewit avenue east of Cedar street the bench extends about a mile and a quarter due northwest through the city. The abandoned sea-cliff is well developed at the corner of East Prospect and Spruce streets, and at that point there was a small rocky island close to the cliff. At the corner of Third and West Hematite streets the upper ridge with lagoon hollow and low cliff is crossed by the Presque Isle Park electric cars. A third of a mile beyond this place the beach turns west and passes south of the driving park. It is crossed again on the Collinsville road a little to the west of the park and the Dead River railroad. We traced it still farther to a point about five miles northwest of Marquette, where it is a distinct beach ridge about a quarter of a mile back from the lake shore. It is also well developed as a cut terrace around the west, south and east sides of Presque Isle Park, about two miles and a half north of the city. This picturesque peninsula was once an island more than a mile from shore. It is now connected with the main land by a sandy neck which was built largely by the waves of the Nipissing episode, but probably finished by the present lake. Besides this, the whole tract north of Dead river and westward along the shore for three miles or more from Presque Isle was filling in with sand. Some remarkably fine beach ridges are to be seen north of the saw mill. At the beginning of the Nipissing stage this whole tract was a shore of rocky reefs among which the sand afterward gathered. From the Pictured Rocks to the point northwest of Marquette this line was traced with almost entire continuity, the distance being about 45 miles.

L'Anse to the Portage Lake Canal. The same beach was found again at L'Anse, at the head of Keweenaw bay. Its altitude is a little less than 20 feet, measured at the back of the terrace. Along most of this shore it appears as a narrow cut terrace, but at a few points it has been entirely cut away by the modern lake. It is very distinctly developed and is a marked feature on both sides of the bay. We traced it northward nearly to Pequaming point, and it apparently rises slightly in that direction. In going by rail from L'Anse to Houghton, the railroad follows the terrace of this beach nearly all the way and it may be seen plainly from the train. It is well developed at Baraga and northward to Fewsville and Newtonville, and again at Chassel, where the railroad crosses the great flats of Sturgeon river. Its altitude at Houghton was not carefully measured, but is not far from 25 feet above the lake. In going by steamer from Houghton out through the Portage lake canal, this beach was seen to extend to the north side of the Keweenaw peninsula. In fact, it was the shore drift of the lake when it stood at this level which filled in the Portage strait of that time and united Keweenaw Island to the mainland. The case here is like that at Sturgeon Bay, Wisconsin; the canal is excavated almost wholly through littoral drift. It cuts through about 30 feet of sand and gravel near the north end, which shows plainly enough that the beach of the Nipissing episode was about at that level at that place.

Again, near the outer end of Keweenaw point, we found this shore line strongly developed at Lac la Belle and along the shore eastward to the extreme point. Its altitude there is about 40 feet above lake Superior. Lac la Belle, like Au Train lake, was a bay cut off by the shore drift of the Nipissing beach. But it was not completely separated until a lower stage. We found this beach also on the north side of the point at Eagle Harbor as a sandy strip at about the same hight as at Lac la Belle. The second reach of the Nipissing beach, extending from Pequaming point to the north end of Portage lake canal, is also about 45 miles in length.

Duluth. Farther west the coast was not seen at low levels except at Duluth and Superior. In that vicinity the Nipissing beach drops nearly to the present level of the lake. Minnesota point, which is about six miles long, and possibly Rice's point also, are great spits which belong mainly to the shore line. They are not more than 10 or 15 feet above the present level of the lake and for this reason they must be attributed to present wave action, but the present shore does not show heavy littoral developments like these anywhere else. Besides, the observed gradual descent of the Nipissing beach toward the west would point to a probable lower level for it at Duluth. There is also another reason which agrees with this expectation. The horizon of the Nipissing beach, in the two stretches described above, shows such a great degree of modification by wave action as compared with contiguous higher ground that the line of demarkation could hardly be missed. The great spits near Duluth are like the Nipissing beach farther east. But the ground immediately above them, the broad terrace upon which Superior is built, is totally unlike that beach, for it is composed mainly of red clay. In one section, about five feet deep, fine horizontal layers or laminations were seen, which indicate that it is a deep, still water deposit. It is hardly possible that so strong a feature as the Nipissing beach at Marquette and the Portage lake canal, implying so long a duration of wave action at one plane, should not be continuous westward along the same shore. But there is nothing above the level of the spits at Duluth which can be correlated with it, and the clay terrace at Superior, which is 20 to 40 feet above the lake, could not have withstood the action of the Nipissing waves.

Sault Ste. Marie and eastward. The great strength of the development of this shore line, taken in connection with the fact that it is only a few feet above the present level of lake Superior, led me for a considerable time to call it the Sault Ste. Marie beach. But by subsequent exploration at Sault Ste. Marie and at other points east of there, and especially at lake Nipissing (an account of which has been given in a preceding paper*), I was forced to conclude that this shore line marks the level of the Great Lakes during the active period of the Nipissing outlet river, and not a higher stage of lake Superior alone. Before visiting Sault Ste. Marie it seemed probable that this beach belonged only to lake Superior and that it began to be formed when that lake became an independent body of water. It seemed probable that its level had been determined by a barrier at the Sault. But this is not the case, for at that place the same strong shore line passes through the valley of the Ste. Marie river and its altitude above lake Superior is about fifty feet. The outlet of lake Superior at that time was not a river, but a narrow strait with a gentle current. There is no recent rock cut worth mentioning at the Sault. Probably part of the river channel below is of postglacial age, but the most of it is certainly preglacial. The sediments of postglacial submergence extend close up to the foot of the Sault, proving conclusively the very short time since the beginning of its present period of activity. Professor Lawson gives the altitude of a shore line on the Canadian side, which I identified as the Nipissing beach, as forty-nine feet above lake Superior. It may be seen as a finely formed cut terrace, with a marked boulder pavement, along the foot of the hill below the new barracks back of the town on the American side; and it has the same character where I saw it on the Canadian side. It is also well developed on Sugar island and the mainland south of it, and also on St. Joseph's island and the Canadian mainland. On both sides of the river at the Sault, the Nipissing beach has an old sea-cliff or bluff at its back, which is the front edge of a wide terrace. On the south side this terrace is composed of finely bedded clay and silt in horizontal layers; on the north side it is reddish boulder clay. Good exposures may be seen in the ditches by the roads where they ascend to the tops of the terraces. These beds are postglacial deep water sediments like those at Superior, Wisconsin. From Sault Ste. Marie eastward along the shore of the North Channel fragments of this shore line were seen near Algoma Mills and at several points 80 to 100 or more feet above lake Huron. West of Worthington on the C. P. railway is a great sand and gravel delta of Spanish river, which probably marks this beach. It is there about 120 or 130 feet above lake Huron. None of these points east of Sault Ste. Marie were closely examined, except those near lake Nipissing, but I have no doubt that this accentuated beach is one continuous shore line from Duluth to the Nipissing pass. Its altitude near North Bay on lake Nipissing is about 160 feet above lake Huron, or about 140 feet above lake Superior, showing a rise of about 125 to 130 feet from Duluth. As is shown in the paper previously referred to, this shore line is definitely related to the ancient river outlet at Nipissing. For this reason I have called this whole line, which seems to be continuous to the west end of lake Superior, the Nipissing beach.

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*"The Ancient Strait at Nipissing", Bulletin G. S. A., Vol. v, 1894. AM. GEOLOGIST, vol. XIII, p. 220, March, 1894.

HIGHER BEACHES.

Marquette. Fragments of beaches were found in a number of places above the Nipissing beach, but over considerable areas where beaches might be expected they appeared to be absent. The hills back of Marquette are mostly cleared and cultivated up to about 500 feet above the lake, and we examined them pretty thoroughly. The soil is of a gravelly, sandy character, strongly suggesting wash by wave action, but hardly anything having definite form as a beach or a terrace was found except near the highest beach. This same washed character of the soil prevails all along this part of the coast of lake Superior. It is of this sort south of Harvey P. O., where we reached a hight at Frazer's Mill of 115 feet, and above Au Train lake and also on the hills between Munising station and Old Munising, which we saw up to 325 feet. No doubt there are shore line forms at intermediate levels in this region, but we did not see any very clearly defined. Some rather doubtful terraces were observed on the steep hillside back of the charcoal kilns at Onota, but we did not have opportunity to examine them closely. Seen from the lake, the coast at Old Munising looked as though it had been submerged up to 80 or 90 feet. On the hill about a mile and a half south of this place we found washed gravel at about 250 feet forming a low ridge facing northwest, but could not see whether it was continuous. On the top of the cliffs at the Pictured Rocks gravelly clay was seen capped by wind-blown sand. In Marquette at Seventh and Superior streets there are dunes about 150 feet above the lake.

Five miles west of Marquette on the Negaunee road in Section 30 a very heavily developed shore line was found at an altitude of about 590 feet above lake Superior. It is composed of a series of massive, low beach ridges of sand, gravel and shingle making a beach plain about 200 yards wide. The ridges are not very clearly defined where we saw them, but there is a lagoon behind the upper one along the base of some rocky knobs which were formerly sea-cliffs. This great beach marks the upper limit of postglacial submergence on this coast. About a mile and a half to the east and 160 feet lower is another irregular, but heavily developed beach, mostly of sand, which encloses a swampy tract about a mile long. There is an old abandoned railroad grade which ascends to the level of this beach from the north, and, turning toward the west, crosses the swamp. The road from Marquette to Negaunee strikes the old grade and follows it across the swamp. At the back of the swamp and in front of the upper beach there are some coarse gravel mounds which appear to be of glacial origin. They are in a rather protected place near the head of the swamp. About a mile east-southeast of the sea-cliff above referred to, and about a mile south of the place where the road crosses the lower beach, is an ancient delta of the north branch of Carp river, which flows eastward and, after joining the main river, empties into lake Superior south of Marquette. This delta is cleared and cultivated and has a farm house upon it. It was not examined closely, but its level is nearly that of the highest beach.

Besides these positive evidences of submergence at this high level, we found equally impressive evidence that submergence did not reach higher levels. Continuing on the same road towards Negaunee, we crossed a low divide about 80 feet above the highest beach and found ourselves in the valley of the north branch of the Carp river about three miles east of Eagle Mill and ten feet above the beach. This valley is filled with terraces and gravel plains on a large scale. They may be seen to best advantage about a mile and a half east of Eagle Mill near the site of an old abandoned iron furnace, where the road ascends to the upper level of the gravel plain. The plain has been partly cut away by the river, leaving bold terraces on both sides about 40 feet above it. On the south side the plain is wide and the road follows it continuously to Eagle Mill. This station is on the main stream of Carp river, but the gravel plain extends across from one stream to the other a distance of more than a mile. The plain is very sandy, but the sand is mixed with a considerable portion of gravel and pebbles with a few boulders, all waterworn. No doubt the gravel plain extends down the valley of the main stream to another delta, but we did not have time to visit it. The top of the gravel plain at the old furnace is about 50 feet above the beach at the old sea cliff. There are immense glacial terraces at higher levels in the same vicinity; but they are not easily mistaken for those of later age, for their composition and position are clearly glacial. We drove to the top of one of these about a quarter of a mile northwest of the station of Eagle Mill where, at an altitude of about 110 feet above the station or 790 feet above the lake, we had a magnificent view eastward over the gravel plains and terraces. Fragments of these gravel plains extend down to the head of the delta of the north branch of Carp river, already described, showing that the same conditions which led to the formation of the delta were also the cause of the gravel plains extending back to Eagle Mill. On the higher ground, above the level of the beach at 590 feet, we saw no trace of a shore line form and no distinctly postglacial gravel plains or terraces, except those described as being related to the delta of the north branch. This kind of evidence makes doubly sure the determination of the highest limit of submergence. The heavy shore line and its related deltas and gravel plains tell the same story which I have so many times learned in other places, viz., that the occurrence of these three formations—beach, delta, and fluvial plain—closely related as in this case, and each so strongly developed, marks a supreme climax in the process of submergence. This combination is particularly characteristic of the highest shore line in all the rough regions of the north.

The valley of Carp river above the highest beach shows another important fact. The gravel plain is built into a fluvial bed previously eroded out of glacial drift, showing quite clearly that a considerable period of subaërial erosion had passed after the disappearance of the ice and before the building of the gravel plain. Farther west, at considerably higher levels, are several lakes and streams which are the head waters of the Escanaba and Michigamme rivers. Some of these streams have gravel plains apparently of the same age as those of Carp river. This is the case with the streams which flow southward and enter into lake Michigamme from the north.

L'Anse. On the west side of the plateau of the Iron Range we found the highest shore line at about 590 feet and developed with about the same strength as at Marquette. The beach at this locality was first seen from the train as we descended the long grade to L'Anse. Afterwards we drove out to it and examined it with some care. It is about seven miles south of L'Anse, where a switch turns south to the abandoned Taylor mine. The beach at this place is of sandy gravel and shingle in heavy and rather irregular, broken ridges, facing toward the northwest. From this place down to L'Anse several distinct terraces were observed, four of which were measured at their front edges and found to be 425, 345, 320 and 240 feet, respectively, above the lake. The soil at low levels in this vicinity contains more clay and does not so strongly suggest wave dash. But the terraces are much more distinct than any observed below 430 feet back of Marquette. The terraces themselves, however, are more sandy and gravelly than the soil below and are deltas of a small stream.

Houghton. On the Keweenaw peninsula shore lines were seen in a number of places. On the high hill back of Houghton a gravel beach ridge very strongly and clearly developed was found on the higher ground back of the Huron mine. It extends towards the southwest from some ledges of rock at a point where the main road crosses the summit of the hill. The form and composition of this beach ridge are typical and its altitude above the lake is about 410 feet. Prospectors' holes on ground 25 to 30 feet higher show the same composition as in the beach. But no distinct shore line form was seen above the one mentioned. At one point by the roadside near the Huron mine there is a rock surface with fine glacial grooves and some nodules with "ice shadows" of the softer rock projecting in the direction of the ice motion. The direction was found to be N. 75° or 80° W. (mag.) About two miles farther southwest on the Ontonagon road another immense beach ridge of gravel was found at about the same altitude. It forms a blunt spit projecting to the southwest and incloses a little lagoon basin about a hundred yards wide and eight or ten feet below the crest of the ridge.

The road passes down through this hollow and over the ridge to the west. We drove still farther out along the Ontonagon road to a point about nine miles southwest of Houghton. But the whole tract was one dense forest and it was impossible to see much of the ground. We crossed a cut terrace on an eastern slope, with sandy soil below it, at a level closely corresponding with the beaches just described, but no beach ridges were seen.

On the hill back of Hancock terraces were observed at about 100, 150, and 200 feet above the lake, and at about 230 feet a broad, gravelly terrace and beach ridge. But we did not examine any of these closely and we saw none higher. Above this, up to about 490 feet, there are water-worn gravels on the surface. All these beaches and terraces were exposed to wave action from the northeast through the gap over Portage lake canal.

Allouez. In the vicinity of Red Jacket and Calumet we did not find satisfactory evidences. In Calumet there is a remnant of a gravel ridge in the railroad yard which may be a fragment of a beach. So little of it remained, however, that no certain inference could be made as to its previous form, and there were elements in its composition which are not characteristic of a beach in that situation. Most of the pebbles were well rounded, but there was a good sprinkling of angular ones and a good many boulders of considerable size. A number of curiously cracked or sutured boulders were found in this bank. The altitude of this gravel ridge is about 600 feet above lake Superior. Following the road northeast about twelve miles towards the old Copper Cliff mine we found very little evidence of submergence, only a few terraces related to small streams. The best one of these is at the foot of the hill beyond Allouez. It is a very distinct terrace and seems to be related to a plane of still water extending northwestward over lake Superior. Two or three more terraces of this kind were found about two miles farther northeast similarly related to other small streams at about the same level. Their altitude above lake Superior is about 400 feet. Although no certain shore-lines higher than these were observed on the peninsula, it is doubtful whether they mark the upper limit of submergence. Neither the ridge at Houghton nor the terrace at Allouez has that composite form which marks the upper line at other places along this coast.

Keweenaw Point. Our opportunity to visit the coast of the outer point came through the kindness of Messrs. Ralph and Arthur Connable, who invited us to join them in a cruise on their fishing tug, the "J. W. Parmelee." We found several fragments of beaches on the outer point above the level of the Nipissing beach. There are faint traces of a beach about 75 feet above the lake back of the copper smelter at Lac la Belle. On the western slope of Mount Bohemia I found narrow terraces at 95, 110, and 120 feet above the lake. They are probably related to a small stream which descends there through a ravine, but they undoubtedly mark the level of the lake at that time. Looking eastward from the roof of the smelter, the southward face of the mountain shows a distinct notch which looks very much like a sea-cliff. Captain Plum and part of the crew of the "Parmelee" made the ascent of the mountain and ascertained by barometric measurement that the top of the backwall of this notch is about 660 feet above the lake. The level of the rock shelf below is about 600 feet above the lake. It is not certain that this is a shore line, but its form and place are suggestive. None of these shore lines, however, were seen to advantage, for the country is rough and heavily timbered. Manitou island, which lies off the extreme point, was probably all submerged at the Nipissing stage. We landed on the west end of it and found there a massive conglomerate including rounded boulders four and five feet in diameter. There are also many faults of small displacement cutting through the pebbles and boulders.

On the north side of Keweenaw point, a fine series of shore lines was found back of Eagle Harbor. One at an altitude of 170 feet above the lake is a finely formed shingle ridge with a depression behind it, and there are several others almost as well developed on the steep slope below. Above this highest ridge are two terraces related to a stream which comes out of a deep ravine at this point. The lower terrace is about 200 feet, and the other about 220 feet, above the lake, both probably old deltas. In driving across the peninsula from Lac la Belle to Eagle Harbor, faint semblances of terraces were noticed near the Delaware mine; and about a mile west of it, at about 580 feet, some gravel deposits which resemble beaches in their composition. But we did not see their form, and it is doubtful whether any of them are shore lines.

Duluth. At Duluth we visited the locality of Prof. Lawson's highest beach at the top of the Seventh Avenue Inclined railway. We did not find the highest beach very clearly developed, but the one next below is well marked. We saw them at a disadvantage, however, as a dense fog was prevailing at the time. We went about a mile farther back to Highland Park and saw there other gravel ridges about 100 feet above Prof. Lawson's highest. From the brief examination which we were able to give them, it seems probable that they are of glacial origin. But our observations were too hurried to be decisive. From Duluth I returned eastward alone, visiting several localities on the south coast in search of the highest beach. On the long, gradual ascent from Superior eastward over the red clay plain only a few faint marks of shore lines were observed until an altitude of about 450 feet was reached. At this level sand begins to overlie the clay.

Maple Ridge. About a mile east of Poplar station, at about 460 feet, there is a magnificent beach ridge and lagoon south of the railroad extending for a long distance. About a mile and a half east of Maple Ridge station, the upper limit of submergence was found very clearly developed as a beach ridge with a depression behind it. Its altitude is about 535 feet above lake Superior, which is the same as Prof. Lawson's highest at Duluth. The railroad crosses the beach and for a mile or two passes over ground above its level. Then it descends again and crosses the beach on the eastern slope west of Blueberry station. Immense deposits of fine gravel and sand were crossed near the Bois Brulé river and two or three other streams.

Iron River. At Iron River the ground was examined with some care, but the results were not decisive. The immense, rolling gravel deposits south of the town are so unlike ordinary littoral features that it seems certain that they are of glacial origin. Still, they are much like certain postglacial deltas which I have seen at several other places. About a mile north of the town and at an altitude of about 510 feet above the lake there is a well formed beach ridge of gravel. On the front of the sand hill south of the town there is a faint terrace at about 555 feet, which may be a shore line, but this is not certain. This place was left with the impression that the highest beach had not been certainly identified.

Kimball. At Saxon the country is so new and there are so few roads that I was unable in the time at my disposal to reach the probable level of the highest beach. No distinct beaches or terraces were seen at this place except some gravelly stream-terraces on Mr. Emory's farm in the valley of the east branch of Potato creek, about two miles southwest of the station. Their age was not determined. But in going by rail from Saxon eastward the highest shore line was crossed, about two miles west of Kimball. Its highest level here is a cut terrace and is well defined. Within a short distance, at slightly lower levels, beach ridges were also seen. The altitude of the highest beach at this place is about 570 feet above the lake.

Bessemer. At this place I found myself entirely above the level of submergence. I drove about seven miles north down the valley of Black river, but saw no littoral or subaqueous forms. Almost the whole distance was in dense forests and thickets. The lowest altitude reached on this drive was about 600 feet. This was in the bed of Black river near North Bessemer station. The valley there is nearly half a mile wide and about 100 feet deep, and it continues northward at least four or five miles in the same character. Its floor is flat, implying the attainment of base-level conditions, and it is interesting to note that this temporary base-level was apparently close above the level of the highest shore line as observed at Kimball and L'Anse. The country surface slopes gently toward the north, interrupted by a few rocky hills and morainic ridges. The lowest place reached on this surface was at the north, where it is about 625 feet above the lake.

Sault Ste. Marie. With the possible exception of two or three small islands near Au Train lake, the entire upper peninsula of Michigan eastward from Marquette was submerged along its lake Superior side. In going from Soo Junction to Sault Ste. Marie the railroad climbs up a long sandy slope to a point two or three miles west of Wellsburg, where it cuts through a heavy beach ridge of gravel with layers sloping downward to the east. The altitude of this beach is about 310 feet above lake Superior or 910 feet above the sea. After examining the Nipissing beach on both sides of the river at Sault Ste. Marie, I drove out the Tarentorus road on the Canadian side about six miles, to the last locality described by Prof. Lawson. Taking all the circumstances together, this locality affords the finest display of postglacial shore line forms which I have seen anywhere. There is a whole series of very massive beach ridges of gravel resting like even, parallel steps against a rough, rocky country, and below the beaches are massive gravel terraces fully as typical of their kind. The ground is all cleared and cultivated, so that the opportunity to see the features described is perfect. Professor Lawson gives the altitude of the highest beach at this place as 414 feet above lake Superior. The slope southeastward to the Ste. Marie river is pretty steep, affording a grand view over the great river and the islands. These beaches rest on a comparatively narrow tongue of land between the valley of Root river on the west and the deep ravine of Silver creek on the east. In going down the Ste. Marie river by boat, on a clear day, the level line of these beaches is easily seen on the hills fifteen miles away. Gravel terraces comparable with these were seen later, on the Canadian Pacific railway, eight miles east of Cartier, in Ontario. If the ground there were as well cleared as at Root river, the shore line forms would probably be equally imposing.

SUMMARY AND CONCLUSIONS.

The following table shows the altitude of the highest beach above sea level at the various localities described. The letter *r* stands for *beach ridge*, and *t* for *terrace.* The altitude given is in each case that of the upper limit of submergence. But where that distinction was not clearly made out, the altitude of the highest shore line observed is given as a doubtful upper limit.

Altitudes of the highest Shore Line of the south coast of lake Superior.

		Feet above the sea.
Surface of lake Superior, mean, 1870-1888, (U. S. Lake Survey)		602
Duluth	*r* (Lawson)	1134
Maple Ridge	*r*	1135
Iron River	*r*	1155?
Kimball	*t*	1170
L'Anse	*r*	1190
Marquette	*r*	1190
Houghton	*r*	1010+?
Allouez	*t*	1000+?
Sault Ste. Marie	*r* (Lawson)	1014

The facts gathered from these two excursions may be summed up briefly thus: The highest mark of postglacial submergence extends from Duluth to Marquette at a nearly uniform level, rising only about 55 feet eastward. Its altitude as a whole, however, is rather higher than would be expected when compared with other parts of the highest shore line in the same basin. Those of Green bay, an account of which was given in the preceding number of this magazine, are much lower, and those at the east end of the lake are also lower. Professor Lawson reports only two strands or shore lines on the north coast, which exceed the hights on the south coast. Both are on Mt. Josephine, where he found terraces at 587 and 607 feet above lake Superior. This single case seems to indicate that the rule of the northward rise of shore lines holds good. But it is hardly evidence enough for a final test. To the west, the altitude of the Herman beach of lake Agassiz near Milnor, N. D. (lat. 46° 15′), according to Mr. Upham's observations, is 1084 feet above the sea, being 482 feet above lake Superior. It is not supposed by him that this beach has any direct connection with the highest beach in the Superior basin. Between the Red river and lake Winnipeg basin and that of lake Superior, a wide area of central and northern Minnesota rises 200 to 300 feet or more above these highest shore lines in the basins on each side; yet it would appear that the mountainous region of the south coast of lake Superior is one of considerable relative elevation, compared with the adjoining region on the west, as well as on the south and east of it. From Maple Ridge a southward descent of a little over four feet per mile would carry the beach over the St. Croix pass at Upper St. Croix lake, 468 feet above lake Superior. There can hardly be a doubt that the highest beach is up to that level. But it does not follow that the pass was an outlet of the water that filled the Superior basin at that time.

While there is no question of the accuracy and high value of Prof. Lawson's observations on the abandoned strands of the north coast, I think it is a little unfortunate that his work was not prosecuted from a different point of view. He finds in substance, that the shore lines there do not indicate any deformation since they were made. After a careful perusal of his work I fail to see any safe basis for this inference. We should not expect much deformation of the lower lines, for they are the youngest of the series. The place to look for marked deformation is in the higher, older lines, and particularly the highest line. On this point Prof. Lawson's work affords us almost no information. Judging by my own experience in the highlands of the south coast, however, it is probable that, on account of the roughness of the higher country, it was impossible to gather much information as to the upper limit of submergençe without the expenditure of more time than seemed justifiable.

There are only four places where it seems probable that

Prof. Lawson found the highest strand. These are at two localities in Duluth, one on Mt. Josephine and one near Sault Ste. Marie. The northward component of distance from Duluth to Mount Josephine is about 65 miles. The altitude of the highest beach at Duluth is given as 534 feet, and that on Mount Josephine as 607 feet; showing a northward rise of 73 feet, or a little over a foot per mile. This is about the same as the northward rise of the Herman beach of lake Agassiz in Minnesota and in North Dakota. An examination of his table shows that out of forty-eight localities explored, beaches were observed in only twelve places at an altitude as high or higher than 390 feet above lake Superior. It seems improbable that the highest shore line can be as low as this at any point. In fact, I believe that that beach was seen only at the four places above mentioned, and two of these are within two miles of each other in the city of Duluth. I would therefore question the value of Prof. Lawson's table, so far as it tends to invite the conclusion that the higher beaches are not deformed. No proof is offered against the proposition that the *highest* beach rises to the north, and that beach is much the most important of all. In fact, the only instance bearing on the question shows a northward rise of more than a foot per mile, as just stated.

Above strand XII,* which marks a hight of about 136 feet above the lake, the number of observations is much too few to warrant the conclusions advanced, especially in the absence of definite knowledge of the altitude of the highest strand. It is not safe to reason, because the low beaches are substantially horizontal, that the highest one must also be horizontal. The Nipissing beach rises about 25 feet from Marquette to Sault Ste. Marie, but between these points the highest beach falls about 175 feet in the same direction. Strands below the highest can not be safely extended by inference from place to place unless the points of observation are very close to each other, or the beach itself, like the Nipissing beach, has some marked and persistent peculiarity. For instance, in the table referred to, it is by no means sure that the strand at 436 feet in Duluth is the same as that at 439 feet at Grand Portage. On every probability except that suggested by the mere coincidence of vertical interval, which is probably accidental, these two strands are not the same.

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*Op. cit., table opposite page 280.

The very exceptional strength of the Nipissing beach all along the south shore led me to hope that it might be identified among the beaches described by Prof. Lawson. Its rise to the north, as indicated between Marquette or L'Anse and Eagle Harbor, is very slight, and unless thrown out of place by very recent deformation it would be expected at an altitude somewhere between 50 and 100 feet along the north shore. Well developed beaches within this limit are described by Prof. Lawson. By a careful comparison of his descriptions of the lower beaches I think the Nipissing beach may be followed with tolerable certainty as far as Pie island, south of Port Arthur, where there is a beach like it at an altitude of 43.5 feet, but beyond that its identity is very doubtful. At several places it was probably removed by a heavy wave-cut at a lower level.

We shall not know the complete history of lake Superior in the great submergence until the highest shore line on the north coast has been definitely located at a number of points, and this will probably require a laborious investigation directed particularly to that end. When this is done it will probably disclose the existence of straits of considerable magnitude connecting the Superior basin with that of Hudson bay across the Hight of Land. One of these straits probably passes northeast over Missinaibi lake, and another north over lake Kenogami; and there may be others across the watershed north of lake Nipigon. The discovery of a great strait over lake Nipissing, and the probable existence of another over lake Tamagaming, northeast of Lake Huron, add much strength to this supposition. There is proof enough that the highest beach from Duluth to North Bay is a unit, and that makes the several straits referred to all arms of one body. It would require several ice dams at widely separated places to hold this vast body of water up. If the existence of straits northward from lake Superior is established, it will settle the case for the upper lakes in favor of open marine connection as against ice dams.

THE KAMES OF THE ORISKANY VALLEY.

By T. W. Harris, Cambridge, Mass.

When the great North American ice-sheet, in the process of its disappearance, shrunk away from over the northern sections of the United States, its retreating edge left exposed to view a varied topography of hills and valleys, the latter stretching across the country in many different directions, dependent in their several cases upon a more or less complicated variety of considerations. In general, however, these considerations may be grouped into two great classes, *first*, the preglacial topography of river courses and intervening hills, which had been settled by the determining factors of declivity, rock structure, etc.; and *second*, the distribution of the glacial detritus upon this more anciently sculptured surface.

As the average thickness of the glacial deposits is relatively small, it is evident that where they were laid down upon a surface whose original topography manifested a considerable relief, they would produce but relatively slight modifications in the courses of streams, and in the general character of the drainage; while upon a surface of slight relief their effect in these respects might be very marked. A good example of this latter state of affairs is afforded by the Charles and other rivers of eastern Massachusetts, which wander about over drift deposits, with occasional excursions upon rocky ledges, in little relation to the preglacial drainage systems of that region.

The valleys of the Oriskany, the Genesee and other streams of central and western New York are, however, cut to a depth of several hundred feet in the horizontal Paleozoic formations of that region; and the topography being thus well marked these streams have therefore maintained, for the most part, their preglacial courses, with few modifications of any great importance. The varied types of glacial deposit, therefore, instead of overwhelming the ancient topography and concealing it under a new topography of their own devising, are themselves regulated and limited in distribution, according to the more powerful lines of environment, within which they find themselves laid down, but within which they can yet produce a certain limited range of effect. Thus most of the rivers referred to still occupy their old valleys, but within those valleys have been subjected to considerable modification of character.

The great trunk lines of the drainage of central and western New York have in general a direction from west to east. They consist, in the main, of lakes Erie and Ontario and the Mohawk river on the north, and the upper branches of the Susquehanna on the south. Between these two lines the principal tributaries flow in general north and south. In many cases it is a noticeable fact that the sources of north and of south flowing streams stand opposite to one another in such a way that a traveler may ascend the course of the one and then, arriving at its source, continue his journey in the same line down the course of the other; the two streams in effect occupying the two halves of one valley, and draining the same in opposite directions. The Oriskany and the Chenango constitute a case in point. The cause of this phenomenon is probably the preglacial invasion of the valley of the stream having the more gradual slope and consequently less erosive power, by the other, which, on account of greater declivity, has more erosive power and being thereby enabled to extend its drainage area more rapidly has succeeded in diverting or reversing the course and swallowing up a portion of the valley of the weaker stream, the evidence of the robbery being preserved in the areal relations of the valley whose drainage has been thus transferred.

The diluvial relations of such streams are therefore peculiar. As the ice-sheet melted away, its edge, gradually moving back from south to north, would necessarily first expose the valleys of the south flowing streams and then the upper portions of the valleys of those which now flow toward the north. In the former valleys would flow rivers copiously supplied from the melting ice and along their courses would be laid down deposits of sand, gravel, etc., in that elongated, forward-strewn form of deposit characteristic of the flood-plains of streams, in which the detritus is constantly being urged along by the impetus of the current. But as the retreating ice vacated the upper portions of the valleys which discharge northward those valleys would appear as enclosed basins, their natural outlets being blocked by the ice-mass which still occupied their lower courses. These enclosed spaces would be filled with water from the melting ice and would obviously discharge across their cols, down the valleys of the corresponding south flowing streams, swelling the volume of the latter and increasing their power as distributing agents for the detritus which they were obliged to dispose of.

The Chenango valley is filled with such deposits, especially in the upper portion, near the town of Hamilton, where the floor of the valley is very level and where the current of the stream, even where swollen by these diluvial conditions, could not have had sufficient force to carry away nearly all the detrital material supplied to it. The col between this valley and that of the Oriskany is very slight, and in fact is concealed beneath the broad meadow lands north of Hamilton, which are of the nature of a transition between the true flood-plain of the upper Chenango and a lake sediment, with which the southern end of the Oriskany valley lake was filled in the early stages of its emergence from beneath the ice.

But as we follow the Oriskany valley northward, we find that it ceases to be thus completely filled. The coarse gravels of the flood-plain occupy a relatively less and less portion of the cross section of the valley, and are seen to be distributed chiefly in mounds and ridges along its sides, while the middle part is occupied through the greater portion of its length, by a flood-plain of increasing width, composed of fine material, lying at a much lower level, and evidently formed by the stream which at the present day meanders through it northward to the Mohawk.

The kames, or irregular deposits of gravel above alluded to, are best seen in the neighborhood of Oriskany Falls; and an excellent view of them is to be obtained from near the quarries, on the road which runs northward from that village along the west side of the valley.

In some cases they have the form of irregular mounds, but in many instances, they appear as short ridges, with undulating crests, which extend out at intervals from the sides of the valley, diminishing in hight as they are followed toward its center, sometimes sinking below the level of the valley flood-plain, and sometimes coming to an abrupt end.

As regards material, they consist of sand and water-worn pebbles of various sizes, composed chiefly of the Lower Helderberg limestones, the Clinton and Salina shales, and the sandstones of the Clinton and Hudson River groups, which crop out along the course of the valley to the north. The sizes of these pebbles are various, ranging from that of a man's head, down.

As regards structure, the kames are coarsely stratified in cross-bedded layers, which always slope southward, as is shown in numerous cuttings along the railroad which follows the valley. The gravel composing the kames, is often loosely cemented together by carbonate of lime, derived doubtless from the limestone pebbles which abound in the mass.

The history of the formation of these kames is simple. As the ice margin retreated down the Oriskany valley, the basin, which it left open, was filled with water from the melting glacier, which it discharged southward over the col into the Chenango valley, after the manner of the classical example of this type of valley history, lake Agassiz, as described by Mr. Warren Upham (Geological Survey of Minnesota, 8th Annual Report, p. 84). In the Chenango valley, a tolerably rapid and continuous current distributed the detrital materials, which had been furnished from the ice, in the form of a long flood-plain; but in the Oriskany valley, where the outlet was temporarily blocked, the stream assumed the form of a lake, through which the water flowed more slowly and without sufficient force to accomplish an even distribution of the coarse gravel which the subglacial streams cast forth. These streams must have been under a considerable head of pressure, and must hence have emerged from the ice with a considerable velocity. This is shown by the fact of their having transported very coarse material; but, on coming to the light, their rapid movement was quickly checked in the quiet water of the lake, and their load of stones and earth was dumped just outside the ice margin. The irregularity of the deposits shows the fluctuating nature of the stream which brought them, sometimes making its exit from the ice at one spot, sometimes at another, according to the courses of the channels beneath the ice, or to the changes in the flow of water through them, as they became in turn choked with accumulated debris or were opened by the melting of the surrounding ice. This process must have continued so long as the glacier occupied the Oriskany valley. When it had retreated to the Mohawk, or at least far enough to open an outlet in that direction at a lower level than the col at Hamilton, the direction of flow of the lake water was reversed; and as the ice abandoned the mouth of the valley, the lake was drained, and the flow of the water which fell in the valley resumed its ancient direction. The Oriskany, shrunken to its present size, began work upon the drift deposits in the valley bottom, and gradually constructed from their re-arranged material the low-level flood-plain that now borders the stream.

Returning once more to the kames, several points of interest occur to the observer. In the first place, why should they appear chiefly on the *sides* of the valley, instead of being distributed across its entire width? To this a number of answers may be given. It might be said, in the first place, that they do extend completely across the valley, but that they are concealed from view, as a rule, in the middle, by the flood-plain of the present stream. Their shape, however, shows that the mounds diminish in size toward the center of the valley; so that, even if they do cover the entire valley bottom, they are largest at the sides. The same argument would apply to the suggestion that they have been diminished through cutting away by the present stream. The appearance of occasional concavities in their outline shows that some cutting has been thus accomplished against them; though the fact that the present stream is accumulating flood-plains of fine material along its course also testifies that it can not have been a very powerful eroding agent. But the fact that the actual sizes of the kames are greatest at the sides of the valley seems to show that the chief points of discharge of the subglacial streams were similarly situated. This may perhaps be best explained as follows: When the ice-sheet covered the country, it spread over hills and valleys alike; but when it melted away, being deepest and thickest in the valleys, it would obviously take longer to melt from them than from the neighboring hills. Hence the melting ice front would have an irregular outline, with tongues of ice stretching down the valleys. Many of the escaping streams of water, therefore, would come forth from the ice at the sides of those tongues, and, flowing along between the tongue and the adjacent hill, would discharge into the lake, and build up detrital deposits at the sides of the valley. Doubtless there were also opportunities for escape at the end of the ice-tongue, in the middle of the valley; but it must be remembered that the bottom of the ice-tongue lay submerged in the lake, and that this water would retard any subglacial stream which might discharge at that point, while the side currents, flowing down from a higher level, along the junction of ice and rock, would have a considerable fall and a more rapid current, adequate to the transportation of much more and much coarser detritus than could be furnished at the end of the tongue. It would be of interest, for any having the opportunity, to test this explanation by observing the distribution of washed drift at the points of discharge of the streams from existing glaciers, could such be found under conditions which present a sufficiently close parallel.

Another fact of interest emphasizes the close connection of these kames with glacial conditions. The materials of which they consist are exposed to view in numerous railroad cuttings, and, as was said above, they contain, among other rock fragments, numerous pebbles of the red Salina shale, which occurs in place several miles further north. This shale is very soft and friable, even where its ledges are excavated to a depth of many feet, and the pebbles themselves are so fragile that it is exceedingly difficult to get one out of the gravel unbroken. Yet they are well rounded, showing that they have undergone considerable battering in their journey; and they are in close association with pebbles of much harder materials, with which they must have been brought into frequent collision on their way to their present resting place. It is easy, therefore, to see that during the process of transportation they must have been much harder than they now are. It is not impossible that their present softness may be due entirely to chemical decay, caused by substances brought by percolating water since their deposition; but the fragility of the shale where undisturbed, even in a fresh deep excavation, makes this at least questionable. It seems more probable that the shale rock had become saturated by percolating water from the surface when the ice sheet advanced over it, and that the low temperature due to the presence of the glacier caused this water to freeze in the interstices of the rock and thereby to cement the rock particles firmly together. In due time the shale, thus frozen, was broken up by the ice, and fragments of it were carried southward in the till and by the currents of subglacial streams and were deposited, still frozen, in their present positions. The freezing and consequent expansion of the water with which they were saturated must have loosened the already slight cohesion of the rock particles still more, so that, upon the melting which followed the retreat of the glacier, the pebbles were left in an extraordinarily friable condition. A somewhat similar instance is mentioned by Prof. J. W. Spencer, who has described (Amer. Naturalist, Oct., 1887) the occurrence of sand boulders, which were broken up and transported in a frozen condition and then were deposited in stratified drift, thus being preserved in form after the ice, which had rendered this process possible, had melted away.

LAKE RONKONKOMA AND OTHER GLACIAL FEATURES OF LONG ISLAND.

By JOHN BRYSON, Eastport, Long Island.

A few weeks ago the writer paid a visit to lake Ronkonkoma, which is situated in the central part of Long Island, about fifty miles from the city of Brooklyn. It lies in a valley between the two moraines, and is celebrated for its beauty. The Indians had many legends and superstitions in regard to it, as it was thought to have no bottom. An air of mystery still hangs over it, as scientists are unable to explain some of the phenomena connected with this wonderful little lake. Only a year or two ago the water began to rise without any apparent cause, threatening to inundate the surrounding country; but before much damage was done the water began to subside as mysteriously as it had risen. The lake is said to have neither inlet nor outlet, and while this is true as to its present status there was certainly a time when it had several affluents as well as effluents. In fact, the formation of the lake was due to the action of subglacial streams that met at this point. I had long suspected this, and during my recent visit it was gratifying to find this conjecture confirmed. It also proves, I think, what I have always maintained, that kettle-holes are really subglacial valleys; for lake Ronkonkoma is only an enlarged kettle-hole.

If the reader will examine a map of Long Island, it will be seen that there is quite a stream draining into Smithtown bay from the region of Ronkonkoma. It forms one of the largest indentations on the north side of the island, and if this depression is followed up it will be found connecting with the lake in question. During the glacial floods the water must have flowed southward through it into the ocean. The largest channel enters the lake on the north, and consists now of a marshy depression. This doubtless formed at one time the main inlet. There are other smaller depressions, or old channels, entering the lake on both sides, and where the old streams met the lake is the widest.

The depression at the south end was probably the main outlet, although there is little drainage, if any, through it at present; but the old channel, or channels, can still be traced through the terminal moraine and southern plain to the Great South bay. The bottom of the lake is several feet below the present level of the sea (I have not the exact figures at hand),[*] and the theory of oscillation has been brought into requisition to account for certain phenomena that cannot very well be explained on any other hypothesis, at present; yet there are serious difficulties in the way, even with this interpretation. Prof. James D. Dana thinks that the island must have stood about 100 feet higher while the ice cap lay over it, and that it sank again to its present level when relieved of its burden. There are no signs of such changes having taken place, if we may judge by the contour of the island, as the old water channels are united in such a way as to preclude the idea of oscillation, and yet there are certain phenomena that seem inexplicable without it. That is, it seems as if the land must have been higher or the sea lower during the glacial floods, to account for the stratified deposits on the southern plain which extend more than 500 feet below the present level of the ocean, and there is every evidence that said deposits were laid down by glacial streams and not by the waves of the sea. There are also stratified beds of sand and gravel on the north side of the island, reaching an altitude of nearly 300 feet above the ocean level, and the evidence shows that the streams that laid down one deposited the other.

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[*] [From Mr. Upham's description of the terminal moraine forming the "backbone" of Long Island, we are able to supply these figures: "Lake Ronkonkoma, the largest body of fresh water on the island, lies exactly in the course of this series of hills. Its area is stated to be about 460 acres; its hight, fifty-four feet above sea; and its extreme depth, eighty-three feet." (Am. Jour. Sci., III, vol. xviii, p. 85, Aug., 1879.)—Eds.]

On my recent excursion along the north side of the island, from Huntington to Port Jefferson, I was more than ever impressed with the evidence of a great deluge. The great banks of stratified material, as exposed in the railroad cuts and along the bay indentations, are perfectly astounding. In face of such evidence, I am not surprised that some writers look upon the glacial theory as a nightmare; for the true till, or unmodified drift, is very slight in comparison with the vast accumulation of stratified material, especially on this portion of the island. Yet, the present writer cannot see how the whole of the drift phenomena can be explained without the presence of an ice-sheet, and it is a significant fact that those who have given the subject the closest study by personal observation are the ones who favor the glacial theory. Looking at the phenomena as seen on Long Island, I have pictured to myself such a scene as may be witnessed in Alaska to-day. Professor Wright, in "The Ice Age in North America," page 54, gives a photograph that might have been taken on Long Island when the glacier was retreating from the Atlantic border, and while lake Ronkonkoma, and other like depressions, were being formed. The lines of moraines, with their kettle-holes and valley depressions, the kame ridges and kame deltas, the boulder phenomena, and the almost universal mantle of silt that covers the stratified deposits, not to speak of the vast deposits of subglacial unmodified drift, tell us of a reign of ice as well as a deluge of water.

With our present imperfect knowledge, there are many things we are unable to explain, even with the aid of the living glaciers of to-day; yet the presence of an ice-cap is needed to render the drift phenomena intelligible. Any attempt to explain them on the diluvial theory alone must lead to distortion and perversion of facts.

THE ORIGIN OF DRUMLINS.

By RALPH S. TARR, Ithaca, N. Y.

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1.—STATEMENT OF THEORIES.

Three theories to account for lenticular hills or drumlins have come prominently before geologists, and there is at present a division of opinion as to the value of these. Of late, however, there appears to be a tendency among the majority of glacialists to look upon one of these as more probable than the others; and there also appears to be a tendency to overlook the fact that there are strong reasons to suspect that one of the other theories may also furnish a true explanation. This paper is written, not with the object of advocating this theory to the exclusion of others, but to bring forward such arguments as the author finds, in his own mind, to be indications that it cannot be neglected as a working hypothesis.

As early as 1870 Professor Shaler* suggested that these peculiar drift hills, in the vicinity of Boston, were the remnants of a sheet of drift, modified by the action of rivers, waves, etc., and obtaining their two prevailing directions from underlying rock cores. He has more recently somewhat modified this view by supposing that a deposit of the first glacial epoch has been worked over and carved out chiefly by ice action.†

A modification of this latter theory is that suggested by

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*Proc. Boston Soc. Nat. Hist., 1870, vol. XIII. pp. 196-201; Illustrations of the Earth's Surface, 1881, p. 63.

†Seventh Annual Report, U. S. Geol. Survey, p. 321; Ninth Annual Report, U. S. Geol. Survey, pp. 550-551.

Hitchcock* and Wright† and held by some others. This suggests that a re-advance of the ice modified the terminal moraine deposits into drumlinoid forms. This theory seems to be generally abandoned, and apparently Wright, in one of his later publications,‡ is inclined to accept the next theory as more probable. It is this theory, however, which the author now brings forward again.

The hypothesis at present most currently accepted was first suggested by Kinahan and Close§ to account for the drumlins of Ireland, and is also advocated by Geikie‖ in England, and by Davis,** Chamberlin††, Salisbury,‡‡ and others, in America. This theory considers these hills to be of constructional rather than destructional origin. That is to say, by variations in current or drift-supply the ice is supposed to deposit more material at one point than at another and to produce the drumlins by successive additions, in a manner comparable with the formation of a sand bar in a river. Professor Chamberlin,§§ and indeed others as well, has assumed the probable existence of a rock nucleus; but it is hardly probable that, in the light of later studies, these authors would now advocate this view.

As has been said, Wright at present advocates this theory; and originally Upham‖‖ also believed this to be the origin of drumlins. At present, with the exceptions of Shaler, Hitchcock, and Upham, there are, so far as I am able to ascertain, no American glacialists, who have expressed themselves on the subject, who do not accept this theory as at least the most probable; and some apparently consider it proven.

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*Proc. Boston Soc. Nat. Hist., 1876, vol. XIX, pp. 63-67.

†Proc. Boston Soc. Nat. Hist., 1876, vol. XIX, p. 58; 1879, vol. XX, p. 217: The Ice Age in North America, Third Ed., 1891, pp. 259-260.

‡Man and the Glacial Period, 1893, p. 75.

§General Glaciation of Iar-Connaught. Dublin, 1872.

‖The Great Ice Age, 1874, pp. 88, 97.

**Proc. Boston Soc. Nat. Hist., 1882, vol. XXII, p. 41: Am. Journ. Sci., third series, 1884, vol. XXVIII, p. 415: Science, 1884, vol. IV, p. 420.

††Geology of Wisconsin, 1873, vol. I, p. 283; Third Annual Report, U. S. Geol. Survey, p. 306.

‡‡New Jersey Geol. Survey, Annual Report for 1891, pp. 71-75.

§§Third Annual Report, U. S. Geol. Survey, p. 306.

‖‖Geology of New Hampshire, vol. III, p. 308; Proc. Boston Soc. Nat. Hist., 1879, vol. XX, p. 233, and also in later volumes.

Recently Upham* has advanced the hypothesis that drumlins are formed *in* the ice by a shearing motion and consequent accumulation.

2—OBJECTIONS TO THESE THEORIES.

Numerous objections have been urged against the last theory, those by Chamberlin† and Davis‡ being particularly strong and proving, apparently, that it is not applicable, at least as a general explanation. Professor Davis suggests, however, that this may be one of several causes for a phenomenon which is conceivably capable of explanation by several different theories.

The explanation suggested by Professor Shaler appears to be open to a fatal objection. This is that, excepting near the surface, the drumlin drift shows no signs of disintegration, and is in no way different from the ordinary glacial drift. Unless the time of deglaciation, or the interglacial period, is conceived to be very brief this theory does not explain the facts.

The problem is therefore reduced to the consideration of the two remaining hypotheses. With reference to the one most currently accepted, the constructional theory, it has always been difficult for me to conceive the overburdening of ice in such a way that it may temporarily and locally deposit these narrow and comparatively small, though relatively deep drift deposits. By what action is this accomplished and in what manner does the process act? These are points which, after a careful study of the literature, I have been unable to understand. This is, I am aware, not necessarily a serious objection to the hypothesis; but before accepting an hypothesis one must find in it either proof or possibility.

If we grant this power to ice, it would appear that there should be some apparent cause for variation in currents and in deposition. But drumlins occur in regions so different that there seems to be no connection with topography or supply. They are found in and south of hard crystalline rocks as well as in friable sedimentary strata; and they occur on plains as well as in the hilly and even mountainous region of New England. One has no difficulty in understanding how drift is accumulated in transverse valleys where the ice was nearly stagnant, nor the manner in which a drift slope may be accumulated on the southern end of a rock hill. There is here an apparent cause for deposition; but it seems to me a much more difficult task to conceive of irregular currents or supply, for which there is no apparent cause, but which, in some manner, shall accumulate narrow and short hills of drift and often a series of complex summits and valleys.

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*AM. GEOLOGIST, 1892, vol. X, pp. 339-362; Proc., Boston Soc. Nat. Hist., 1892, vol. XXVI, pp. 2-17; Bull., Geol. Soc. Am., 1893, vol. IV, pp. 9, 10.

†Journal of Geology, 1893, vol. I, p. 259.

‡Proc. Boston Soc. Nat. Hist., 1892, vol. XXVI, pp. 17-23.

Another objection to this theory is that there are so few indications of lenticular stratification. If these hills are built up by successive additions it would seem that there should be, at least commonly, some indication of this growth by a kind of stratification or lamination parallel to the drumlin outline. While in some sections this is apparently present, in general it is absent. Sections of drumlins usually exhibit either massive till or a mixture of till and stratified drift, morainic in aspect.

The presence of stratified drift, which in the following pages is shown to be by no means uncommon, must be explained by any hypothesis which is put forward to account for drumlins. How is it possible by this theory to explain the alternation of loose stratified gravels and compact till? The compactness indicates a weight of superincumbent ice. Would a sheet of ice sufficiently massive to cause the compression thus indicated, change its nature so that flowing water should deposit modified drift? And how does it happen that this peculiarity exists *in* the drumlins and is so generally absent in the general drift sheet near by?

The peculiarity of distribution should also be explained. They are local deposits, sometimes isolated, but more commonly in clusters, and over large areas of glaciated country they are entirely absent. These facts are certainly remarkable; and if drumlins are the result of variation in ice currents, or drift supply, it evidently requires peculiar conditions for the existence of these irregularities. These conditions should be apparent, or at least indicated; but, so far as I know, no one has discovered what they were, nor attempted to explain them.

The more important objections to the hypothesis that drumlins are forms produced by the partial destruction of some mass of moraine as a result of a re-advance of the ice, are found in the following sentences from Upham's recent paper.* He says.—

"If this view were true, the till of the drumlins could not have its nearly uniform character, but would contain here and there remarkable aggregations of boulders; and frequent irregular enclosures of sand and gravel would be found, representing the kame deposits and lenticular beds of modified drift which so commonly make up considerable parts of the terminal moraines. Salisbury remarks that neither the distribution nor the composition of the drumlins seems to favor this hypothesis, and he therefore believes that they were built up beneath the ice, not being fashioned from hills overridden by it." These objections may be left unanswered for the present, since they are considered below.

3.—Indications of Destructional Origin.

(a) *Distribution.*—There is every gradation between sheets of till and typical drumlins. Chamberlin† divides these unstratified drift deposits into (a) till tumuli, (b) mammillary and lenticular hills, (c) elongated parallel ridges trending with the ice movement, (d) drift billows, (e) crag and tail, (f) precrag and combings, (g) veneered hills, and unclassifiable till hills. Pointing out that they are somewhat allied to moraines, he says that there is "a richness of variety and intergradation that almost defy classification."

This gradation, while in places very striking, is not always present and is not of itself proof that the drumlins are merely a stage in the accumulation of drift. It would be equally well explained by the opposite theory, that they are hills of destructional origin derived from a preëxisting moraine or from a drift sheet of irregular thickness. Indeed, the peculiarity of distribution of drumlins suggests to my mind the latter rather than the former origin. While there is every gradation between the most perfect lenticular hill and the undifferentiated ground moraine, the true drumlins and the drumlinoid till slopes of various kinds are strikingly local and irregular in distribution.

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*Proc. Boston Soc. Nat. Hist., 1892, vol. xxvi, p. 7.

†Proc. Am. Assoc. Adv. Sci., 1886, vol. xxxv, p. 204.

The greater part of the drift-covered area is free from these hills; and where they do occur they are generally bunched together. There is, moreover, in parts of New England, a striking parallelism between chains of drumlins and bands of moraine. While the individual hills have commonly a north and south extension, collectively they have an east and west grouping.

Also, just as the moraine is thicker in some places than in others, so they are more numerous and deeper in certain areas than in others. At times their depth is considerably greater than the deep part of the till sheet in the area. These facts suggest a certain likeness between moraines and drumlins which must be kept in mind in studying the origin of these peculiar hills.

(b) *Resemblance to Drumlinoid Rock Hills.*—There can be no student of glacial geology who has not been struck by the marked resemblance between drumlins and drumlinoid rock hills in glaciated areas. In my own case, although reared among the drumlins of the Boston region, I was, in my first glacial work in central Massachusetts, misled into classifying rock hills as drumlins on the basis of their form alone. The gneiss hills of New England are in many cases drumlinoid in outline; and at times the resemblance between a thinly drift-coated hill and a drumlin is most striking. Even hills barren of till are frequently lenticular.

While this is true for New England it is even more typically shown in central New York. There are scores of hills in that region, which, in a photograph, could be easily passed for typical drumlins and which need a visit to prove that they are not drift hills.

There is a certain rhythm of ice erosion which expresses itself on a small scale in the production of *roches moutonnées*, on a larger scale in the carving of drumlinoid rock hills, and, I believe, on a still larger scale, in alternations of erosion and comparative freedom from erosion at intervals of many miles.*

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*This point is presented in a paper in the Bull. Geol. Soc. America, vol. v, 1894, p. 352.

What the reason for this rhythmic action is, I am not prepared to say; but that ice erosion normally distributes itself unevenly, with the ultimate result of producing rounded, lenticular forms with axes in the direction of ice motion, it seems hardly probable that any one can question after seeing the rock hills of New York and New England. Nor is this due to differences in hardness or attitude of the rocks, for in central New York the strata are of comparative uniformity and nearly horizontal. It appears to be an expression of the effort of the moving ice to produce a slope of least resistance; and this slope appears to be the flat drumlinoid slope. Depressions are filled with drift, and the projections are worn down: and when the ice disappears the hill may be veneered with drift. This curve of ice erosion is beautifully shown on the sides of some north and south valleys, one of the most typical instances known to the author being in the valley of Cayuga lake. I believe it can be stated that it is a law of ice erosion to produce rounded, lenticular slopes.

(c) *Drumlinoid Form of Overridden Moraines.*—In the moraine at Cape Ann, Massachusetts, there are drumlinoid forms, not perfect drumlins it is true, but forms simulating these, with their axes in the direction of ice flow. That these are moulded by the ice as it formed the moraine seems evident; and they appear to be illustrative of a stage between moraines and drumlins.† While these are not as perfect as true drumlins nor as drumlinoid rock hills, being in a moraine the resemblance is noteworthy. Others have pointed out the same lenticular tendency in morainic hills.

(d) *Flutings on Drumlins.*—One other point which favors the destructional rather than the constructional theory is the presence of fluting on drumlins. In Massachusetts, benches and grooves, which from their small size appear to be grooves in reality, are frequently found on one side of the hills. At least it would seem to the author very difficult to explain them by variations in currents.

4.—CONSIDERATION OF OBJECTIONS TO DESTRUCTIONAL HYPOTHESIS.

There are certain objections which must first be explained before this theory can be generally accepted. At present these objections cannot be conclusively answered. More facts are necessary before this or any other theory for their origin can be considered proven; but there are a sufficient number of facts in our possession to make it worth while to retain this theory in the list of possible explanations. Since the tendency is so strongly away from this hypothesis and since these facts have never been formulated, they are brought forward here.

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†Ninth Annual Report, U. S. Geol. Survey, p. 551.

(a) *Assumed Absence of Stratified Drift.*—It is said that if these hills are modified moraines they should show morainic structure. Instead of the dense till there should be a greater or less admixture of sand.

i. General absence of sections.—It seems a question whether this objection is well taken. In the first place how many drumlins are there which have been exposed in complete section? Railroads do not ordinarily cut through them, there are only a few upon the sea coast and only rarely, near large cities, are they breached deeply for purposes of grading. Not one drumlin in a hundred has been cut to a sufficient depth to reveal its true structure. They may be prevailingly stratified in the core. If, therefore, it is shown that there are numerous instances where drumlins, when cut deeply, are found to be stratified, an important point has been gained in answering this objection, for this will show that a considerable percentage of known cuts exhibit stratification.

ii. Moraines not always stratified.—The point just made is strengthened by the fact that moraines are by no means universally stratified. The island of Cape Ann, Massachusetts, is covered by as distinct a moraine as one could desire; yet, in the hundreds of sections, no stratified drift is found in the true moraine. On the moraine and in front of it there is modified drift; but the morainic peaks are unstratified. The same feature is noticed in central Massachusetts. These retreatal moraines, formed during a brief stand of the ice, appear to have been dumped with very little modification excepting in the valleys. Even the terminal moraine of the second glacial epoch, in the vicinity of Ithaca in central New York, is very frequently shown to be unstratified on the uplands and to be composed of true, compact till. Therefore it is not necessary to assume that all drumlins should be stratified; and, even if this were necessary, we have a right to ask that proof be furnished that they are *not* commonly stratified in the core.

iii. Drumlins containing stratified drift.—We have very few descriptions of drumlin sections, but those which we have are mainly of drumlins containing stratified drift. This is natural since the current assumption is that these hills are composed of unmodified till; and variations from this are naturally noted, whereas verifications of the assumption are often not considered worth recording. It is, therefore, not fair to place too much stress upon the preponderance of this class of references. The author, in a rather extensive study of the drumlin areas of Massachusetts and Connecticut, has rarely seen deep artificial sections in drumlins; but such sections as have been observed are mainly in compact till. In the numerous sections naturally exposed in the sea cliffs of the Boston Bay region, till is, in many places, found even in the core.

Nevertheless, where deep cuts have been made in drumlins, stratification quite unlike that found in true till has been frequently observed. Upham* describes the two drumlins at Scituate, Mass., which, where they are breached by the sea, are called Third and Fourth cliffs. These are undoubted drumlins, yet they have a core of stratified gravel intimately mixed with unmodified drift arranged in more or less parallel layers. There are no signs of shoving action, and Upham considers that these deposits furnish evidence of rapid subglacial (his belief is now that they are englacial) accumulations. But it appears difficult to account for the association of the very compact till with stratified drift, since the one must have been deposited under considerable ice pressure and the other under the opposite conditions and from running water. That these alternations of conditions should have taken place, and particularly that they should have occurred in the narrow drumlin areas is certainly remarkable. It would seem that there is a much better accordance of the facts with the theory that these alternations are morainic and that the hills are modifications of a morainal mass.

The same author says† that some of the New Hampshire drumlins are in part stratified. He also observes that a drumlin in Somerville shows stratification, and that, according to Mr. W. W. Dodge,* the drumlin of Fort Hill, Boston, was shown to be stratified when it was partly cut away some years ago. Dodge† also states that Great Head at Winthrop, Massachusetts, has a stratified center; and this induced him to conclude that, although the hill had a drumlinoid form, it was not in reality a drumlin. At Revere, Massachusetts, near the line of the Eastern railroad, there are two drumlins which, a few years ago, showed much stratified drift in sections.

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*Proc. Boston Soc. Nat. Hist., 1889, vol. XXIV, pp. 228-242.

†Proc. Boston Soc. Nat. Hist., 1889, vol. XXIV, p. 238.

The best instance of a drumlin with a stratified core, and one more suggestive of morainic origin than any other seen by me, was found four years ago at Gardner, in central Massachusetts. The description of this has never been published; but it will appear with the atlas sheet of that region in the forthcoming series published by the United States Geological Survey and prepared under the direction of Prof. Shaler. The hill in question is a typical drumlin in the western outskirts of the town of Gardner. At the time when it was studied there was a gravel pit in the southern end, and in this pit there was revealed the most typical morainic structure. Beneath fifteen or twenty feet of the dense till so characteristic of the normal drumlin surface, there was a confused, cross-bedded gravel, with alternate layers of till, all arranged in a confused manner. There was no sign of lenticular stratification, but the gravel had the shoved appearance so common in moraines, and the surface was irregularly eroded so that the till covering was irregular in thickness. At the time I was convinced that it was an overridden moraine; and, as I have considered the problem since then, the conviction has grown as other similar evidence has accumulated.

In describing the drumlins near Syracuse, New York, Johnson‡ states that they are stratified; but he accepts Geikie's interpretation of the origin of this class of hills. In referring to the same region, Upham§ quotes Davis as follows:

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*Ibid., p. 237.

†Am. Journ. Sci. (3), 1888, vol. xxxvi, p. 56. See also Upham, Proc. Boston Soc. Nat. Hist., 1889, vol. xxiv, pp. 132,237.

‡Annals New York Acad. Sci., 1882, vol. II, p. 257.

§Proc. Boston Soc. Nat. Hist., 1889, vol. xxiv, p. 238.

"Professor Davis tells me also that in the southern part of the belt of very abundant drumlins in central New York, their sections frequently show stratified gravel and sand underlying the till, and that often the relationship of these formations is such as to prove that the stratified beds were somewhat eroded before the accumulation of the till, as by an advance of the ice-sheet over a preglacial or interglacial deposit."

(b) *Assumed Absence of Boulders.*—The absence of abundant boulders in these drift hills is also appealed to as evidence against this theory. In the first place, boulders are not always so infrequent as at first sight they appear to be. At times an abundance of boulders appear on or in the drumlins. Upham* states that there are plentiful boulders in the drumlin of College Hill, Medford, Massachusetts, and Johnson† says that there are numerous boulders on the drumlins of central New York. For reasons of location and soil, the drumlins, in New England at least, have been converted into farms and the boulders, which were undoubtedly originally strewn over the surface, have in part been incorporated into stone walls and foundations for buildings.

That many and often large boulders occur in drumlins is proven, in the Boston Bay region, where the sea has encroached upon them. The sea cliff is faced with boulders at its base, and where, as has sometimes happened, the hill has been nearly completely destroyed by the waves, there sometimes exists a line of large boulders marking the drumlin site.

But, so far as my observations extend, the boulder-strewn moraine is the exception rather than the rule. Only where peculiar conditions of supply and transportation existed, are the boulders numerous. Hence ordinarily, the drumlins, if of morainic origin, need not contain a much larger percentage of boulders than does ordinary till. In the particularly rocky moraine of Cape Ann, Massachusetts, the greater part of the boulders are on the surface, and these, at the first advance of the ice would be swept away. Moreover, if the theory here presented is true, such boulders as remained would be buried beneath a till sheet not unlike that which forms the great ground moraine.

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*Proc. Boston Soc. Nat. Hist., 1889, vol. XXIV, p. 237.

†Annals, New York Acad. Sci., 1882, vol. II, p. 255; Trans., New York Acad. Nat. Sci., 1882, vol. I, pp. 77-80.

(c) *Peculiarities of Distribution.*—It has been stated* that the distribution of drumlins does not favor this hypothesis but, so far as I can ascertain, no condusive reasons have been put forward. Certain reasons have been suggested in an earlier part of this paper why the author draws exactly the opposite conclusion. These reasons need not be more fully referred to here; but it may be remarked that, if the distribution of drumlins is opposed to the theory under discussion, a statement of the reasons is called for.

5.—RESTATEMENT OF DESTRUCTIONAL HYPOTHESIS.

There seems to the author to be a sufficient body of fact, and a sufficient number of indications favoring the destructional hypothesis, to call for a reconsideration of it. Taken in connection with the form of rock hills these indications form an argument which must at least be answered. *It is certain that glacial erosion can produce drumlinoid forms*; is there any other kind of ice work of which as much can be said?

Grant a deposit of drift, a moraine let us say of variable thickness and composition, overridden by the ice during a re-advance; in what manner would its removal be accomplished? and would there be any difference between the forms produced from a drift sheet and those resulting from the erosion of an irregular but uniform rock mass?

The first question which arises is, would ice erode equally in all parts of such a till mass? or would not some point be eroded more rapidly than others, either by reason of softness, or original form, or abundance of erosive material in the grasp of the ice? Once an irregularity of work is begun, would it not continue? and would not the resulting form be the same as that which is produced in a rock of uniform texture? In the latter case the forms produced are gently irregular lenticular slopes of least resistance, rounded rock hills whose size and details of outline depend upon the swing of the erosion curve. The same form is present in drumlins, and it is a fair question to ask if it is not probable that the same cause has operated.

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*R. D. Salisbury, Annual Report, New Jersey Geol. Survey, 1891, p. 73.

Rivers for a similar reason meander through their flood-plains in a series of beautiful curves changing in form and position. Ice is commonly compared to rivers in its modes of action, and this has been done even in connection with this very subject of drumlin formation; and now I ask, may not ice have the same habit as meandering rivers? If this be so, drumlins are an expression of the alternating, rhythmic erosion curve—they are the boundaries of the ox-bow curves of the ice stream.

This much for the general subject; we have even less that is explicit for the details of the process. But a moraine overridden by the ice would certainly be subjected to marked changes, and these, as the writer conceives them, are somewhat as follows. The surface portion would be ground finer, and, if stratified at the beginning, might have its stratification destroyed and its sandy structure changed to true till by the grinding action of the ice. It would at the same time become more compact. This material, added to the ground moraine deposited by the retreating ice, might well leave a coating of true till with a depth of fifteen or even thirty feet, so that, unless cut deeply, the original stratification would not appear in the drumlin. This is certainly the condition indicated at Gardner, Massachusetts, and may well be suspected in other drumlins.

It is not the author's intention to insist that this theory is a true explanation, much less that it is the only explanation; but, rather, to urge that it be not too easily put to one side. As investigations proceed, new facts will be discovered, and it is safe to predict that eventually the true explanation of drumlins will be found. In the meantime, if this theory does furnish the real explanation, the proof of it will be more easily and more quickly discovered if investigators bear in mind that it is by no means a disproved theory, as some students of glacial geology seem to assume.

This can certainly be claimed for the theory: that it is not impossible, and that no vital objections have been urged against it; but that, on the contrary, it is the only theory that has more than mere hypothesis to support it. Rock hills of drumlinoid outline are thus carved by ice erosion; and, if this be true of rock, why may it not also be true of incoherent drift? There are certainly reasons to suspect that this may be so; but there are few facts to indicate whether the original material may have been ground or terminal moraine.

6.—SUMMARY.

Briefly stated in summary, the argument of the present paper is as follows:—The theory for the origin of drumlins which is most currently accepted has certain objections which must at least be considered and explained. These are, first, the fact that there has been no adequate explanation of the manner in which the irregular currents act in building these drift hills; second, that there is no apparent association with topography or supply; third, that the drumlins are so irregularly distributed; fourth, that there are so few signs of internal lamination parallel to the drumlin outline; and, fifth, the presence of stratified portions in many drumlins.

A second theory, that of origin by a partial working over of morainic or other drift deposits, once proposed, but now more or less generally abandoned, has certain facts in support of it which appear to be overlooked. Attention is called to the fact that drumlins are locally and peculiarly distributed. They are in places parallel to moraines, and their irregularity is often similar to morainic irregularity. The drumlinoid outline of *roches moutonnées* and of rock hills is also pointed out, as well as the presence of partly lenticular hills in moraines. These appear to be expressions of an effort on the part of the ice to erode a slope of least resistance which is strikingly like the curve of the drumlin. They are compared to the action of a meandering river which is carving ox-bow curves.

Objections to the theory are of three kinds: first, the assumed absence of stratified drift; second, the apparent absence of boulders; and third, the peculiarities of distribution. A number of instances are cited from Boston bay, New Hampshire, central Massachusetts, and central New York, to show that the phenomena of stratified drift and abundant boulders are present in many drumlins. It is also shown that deep sections in these hills are rare, and that a moraine overridden by the ice would probably be coated with till, which, without a deep section, might easily be assumed to be typical of the entire drumlin, while, in reality, the core might be stratified moraine. Since many portions of moraines are practically unstratified, the proportion of known drumlin sections in which stratified drift is found is significantly large. The conclusion is, therefore, that this theory must be kept as a working hypothesis, even if it is not accepted as the most probable theory.

PECULIARITIES OF THE MYSTIC COAL SEAM.

By H. Foster Bain, of the Iowa Geological Survey, Des Moines, Iowa.

The great simplicity of structure exhibited by the Paleozoic formations of the Mississippi valley has been frequently emphasized. The earlier workers in the coal fields of this region, influenced largely by the then preconceived ideas of the close parallelism of beds, sought to find this same simplicity in the minutiæ of the coal-bearing strata. A high stratigraphic value was given to the different coal seams upon the supposition, in part at least, that the individual veins were practically co-extensive with the Coal Measure area. Thus Owen* mentioned the finding of five coal seams in Iowa and doubted whether more would be found. Hall† regarded a certain limestone band in the Lower Coal Measures as recognizable from northeastern Ohio to Kansas. Worthen‡ correlated the coals found at Peoria, Illinois, with those of the Kentucky section established by Owen,§ and found, as he thought, a close agreement.

Owen's scheme was the first attempt to classify the coal beds of the western basin and it was more or less extensively adopted by later writers. Cox‖ discussed these correlations and showed that much confusion had resulted from them. The numbering or lettering of the different seams early attempted was of little value and led to such titles as A, A^1, A^2, A^3. White in Iowa attempted rather to name them, and in 1870 gave six coal seams as occurring in the "Middle" Coal Measures,¶ some of them being considered to extend from Guthrie county to Lucas county.

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*Geol. Sur. Wisconsin, Iowa, Minnesota, p. 97, 1852.

†Geology of Iowa, vol. I, p. 134, 1858.

‡Geol. Sur. Illinois, vol. I, p. 53, 1866.

§Geol. Sur. Kentucky, vol. III, pp. 18-24, 1857.

‖Geol. Sur. Indiana, Ann. Rept. 1870, p. 168, 1871.

¶Geology of Iowa, vol. II, p. 273, 1870.

In this state the attempts to correlate individual seams have not proven to be successful and have led to much confusion. Recently a complexity, rather than a simplicity, has been found to exist, and it has become recognized that the individual beds of the Lower Coal Measures, at least in the Iowa-Missouri field, are characteristically non-persistent. This was in some cases alluded to by the earlier workers, but little stress was placed upon it. Recently it has been elaborated quite fully and interpreted as the result of the conditions of deposition; the Lower Coal Measures being regarded as marginal depositions, and the Upper Coal Measures as representing the marine beds which were deposited, in part at least, contemporaneously.

Complexity of structure, due entirely to the non-persistent character of the beds themselves rather than to deformations, has been so widely recognized in Iowa and Missouri that it has been with extreme caution that particular coal seams have been correlated with those of other localities, and in no case hitherto described has the continuity of a single bed been ascertained to extend more than a few miles. Natural exposures and connecting sections along streams show that the Lower Coal Measures of Iowa are made up of a complex interlocking series of beds of shales, sandstones and limestones, with occasional coal seams. Although, as a rule, these are all prevailingly non-persistent, a few of the limestone bands and some of the sandstones have been found to cover considerable areas. The individual coal seams, however, are generally quite limited in areal distribution.

In marked contrast to this general character is a seam at present worked in Appanoose and adjoining counties in southern Iowa. As compared with other coal seams in the state, the extent of the one in question in quite exceptional. Its distribution so far as traced up to the present time is shown on the accompanying sketch map (fig. 1). It is known to extend over a distance of nearly fifty miles north and south and at least forty miles east and west. There is probably no other vein in the Lower Coal Measures of Iowa which extends unbroken over an equal stretch of territory. Throughout its extent it preserves nearly uniform characteristics which make its recognition easy and secure.

At Mystic it is typically exposed along Walnut creek and a considerable mining industry has been started. The details shown here are as follows:

		Ft.	Inches.
7.	Limestone, massive, gray, well exposed at the Lodwick mine	2	6
6.	Shale, bituminous	1	
5.	Coal	1	6
4.	Clay parting		2
3.	Coal	1	
2.	Fire clay	1	3
1.	Limestone, gray, subcrystalline, exposed in the bluff, where *Productus muricatus* N. & P., *Chonetes mesoloba* N. & P., *Athyris argentea* Shep., *Productus costatus* Sowerby, and other forms, were collected	2	10

The character and thickness of these layers vary but little. The upper limestone, called by the miners the "cap rock," becomes in places, notably in the mine of the Seymour Coal Company in Wayne county, quite bituminous. It is sometimes thicker and is usually immediately covered by a black pyritiferous shale. The shale under it (No. 6) shows perhaps the greatest variation. The upper portion frequently becomes

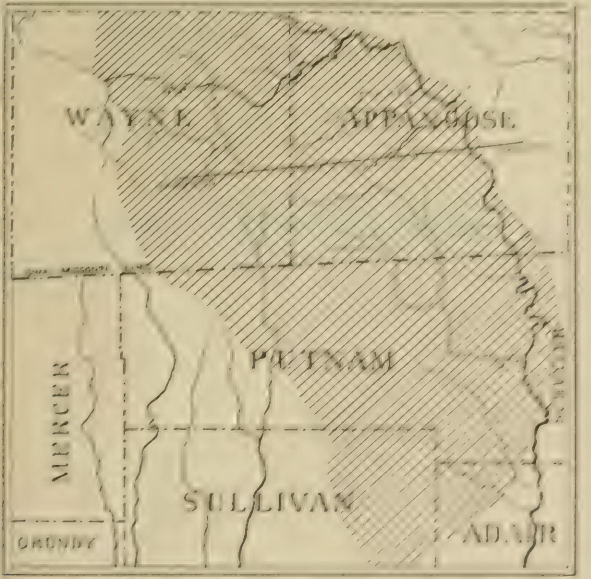

FIG. 1. *Sketch map showing the area of the Mystic coal seam.*

more argillaceous, quite soft, and is known as "clod." At Stahl, Adair county, Missouri, it is said to become two or three feet in thickness. The total thickness of the coal varies within limits of only a few inches. The clay parting (No. 4) is especially notable in its persistency and uniformity. A second parting, from a half to three-quarters of an inch in thickness, is in many places present about three inches from the bottom of the lower bench. In mining, the lower limestone is not always encountered, as the fire-clay frequently thickens considerably.

Not less striking than the extent of the Mystic coal seam is the simplicity of the structure of the region. In addition to the two limestones mentioned above, there are two others, known locally as the "seventeen" and "fifty" foot limestones from their general occurrence at those hights above the coal. These levels are not absolutely correct, but the variation from them is usually slight. The intervening spaces are filled with various argillaceous shales.

A section along the C. R., I. & P. railroad from the east side of the Chariton river in Appanoose county to Harvard in Wayne county, is represented in figure 2. This shows the general simplicity of structure and the prevailing dip to the southwest.

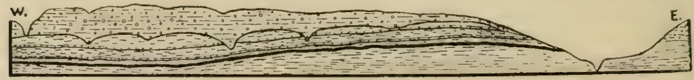

FIG. 2. *Section from Sharon to Harvard.*

The coal is approximately level, yet it exhibits considerable variation in elevation. At Dean, in the southeastern corner of Appanoose county, it is 825 feet above the sea level; at Cincinnati,in the southern part, 995 feet; at Centerville, in the central part, 880 feet; at Mystic, 908 feet; at Numa, seven miles southwest, 900 feet; and from there it dips southwest nearly ten feet per mile to Seymour, where it is 839 feet above sea level. Thence it rises slightly to the west. It is thus seen that Numa and Cincinnati are situated on the crest of a slight anticline, which apparently has a northwest to southeast direction. Other small anticlines are doubtless present in this field, but sufficient detailed work has not yet been done to locate them.

The ready discovery of folds in the Lower Coal Measures is, as a rule, a matter of considerable difficulty, and, indeed, they can only be accurately traced in exceptional cases, such as the one described, in which easily recognizable beds are present over a considerable territory.

Striking as the contrast between the Mystic and other coal seams of the region is, as regards the extent and simplicity of structure, the remarkable uniformity of its physical characteristics is no less noticeable. In hand specimens the coal, though rather soft, is clean, and presents a smooth, glistening surface with a luster almost indistinguishable from that of anthracite. It is intersected by numerous joint planes crossing one another at right angles and filled with thin films of calcite.

It has been said that the limestones which are found near the coal seams are quite fossiliferous. As might be expected, they present a well-marked marine facies. In some instances certain of these species are found in the shale which immediately overlies the coal. Frequently this shale graduates insensibly into a bituminous limestone. The peculiar constancy of physical character, exceptional in western coals, and the intimate relations with marine strata, lend a certain suggestive interest to the theory proposed by Mohr* for the origin of coal under maritime conditions. While his idea that coal was formed from sea-weeds has never received much support in this country, it seems not impossible that for certain particular seams, admittedly formed under peculiar circumstances, this may be found an adequate explanation.

ORIGIN OF ANTHRACITE.

By Charles Rollin Keyes, Des Moines, Iowa.

The transformation of woody tissue into ordinary coal involves a continual loss of the hydrocarbons which go to make up so large a proportion of the original plant mass. As the ultimate result of the process anthracite is formed. While the exact physical conditions necessary to effect the changes are not yet perfectly understood, it is well known that the last stages of mineralization may be arrived at in a variety of ways. Just which method has assumed greatest prominence in each particular case is difficult of ready solution, since it is quite probable that in most instances several very different agencies have acted simultaneously.

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*Geschichte der Erde. Bonn, 1875.

The changes in character which vegetal materials undergo when shut off from the free access of the air, in the presence of moisture, with an even temperature or increased heat, and under some pressure, are very different from those which occur when the mass is exposed to ordinary atmospheric influences. Instead of rapid oxidation, as in the latter case, the various chemical components react among themselves, producing finally ordinary coal. The researches of Bischof* show clearly that the conversion of woody matter into coal is accomplished in at least three ways. By each method the carbonic acid escapes; the hydrogen goes off either as CH_4 or H_2O, in the latter case with or without the aid of meteoric oxygen. Both mining operations and stratigraphical work upon individual coal beds indicate plainly that a loss of the hydrocarbons is constantly going on; that this loss is comparatively speedy in the beginning, or for a short period after the vegetal mass is buried; but that gradually the rate becomes less and less rapid, until in the end the escape of the volatile matter ceases almost altogether. Additional pressure arising from the deposition of sediments upon the plant beds naturally hastens the normal process of eliminating the continually generated gases. Increased temperature likewise tends to have the same effect. Still more favorable to the production of like results is the action of orogenic movements.

In a recent paper† Stevenson has advanced some views on the anthracite of Pennsylvania which differ materially from the commonly accepted opinions concerning the genesis of the beds. In substance, they are that from the northeastern corner of the great coal bed the old marsh extended westward on advancing deltas, and that, consequently, along the marginal portions of the beds the plant accumulations, being less rapidly covered up, were subjected to the ordinary influences of decomposition for a much longer time than in the more central portions. In the middle of the swampy region common bituminous coal was formed; along the edges, anthracite. According to the hypothesis advanced, the coal marshes must have skirted or fringed stationary or slowly rising shores, and the principal changes in the character of the plant masses are regarded as taking place before these were covered by sediments to any great extent. In consequence the vegetal deposits must have passed through practically no changes since the time of their original burial.

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*Chemical Geology, vol. I, p. 274.

†Bulletin, Geol. Soc. America, vol. v, pp. 39-70; Nov., 1893.

In regard to the formation of coal marshes in general, nearly all evidence available goes to show that the plant remains accumulated along slowly sinking shores where the subsidence was interrupted somewhat from time to time. The swamps would thus be constantly advancing inland and not seaward, which last might be inferred from what has just been stated; they would gradually creep up the shores, instead of outward with the growing deltas. Closely following the peripheral swamp deposits, the beds formed in the more open sea would extend farther and farther landward, as the sinking took place, slowly covering the areas formerly occupied by coastal marshes. This appears to be clearly the case in the Central and Western Interior coal fields, where the stratigraphical arrangement is much more simple than in the more eastern districts. But in the fields of the Mississippi basin, in Iowa and Missouri especially, there are coal beds which appear to have originated under very different physical conditions from those under which most of the coal seams of the region were formed. A notable example of this kind is the Mystic vein, which is the most extensive individual bed at present known in the entire field. Its extent and continuity have been definitely made out for upwards of fifty miles in one direction and over forty in another. The vegetal accumulations were made under conditions manifestly maritime. Evenly bedded limestones a few feet in thickness occur a short distance above and below the coal; and other but thicker limestones exist seventeen and fifty feet above. Throughout the entire extent of the Mystic area there is a remarkable uniformity in the thickness of the coal and its associate strata. Still more remarkable is the character of the coal itself. Although a bituminous variety, it has the subconchoidal fracture, the bright luster, and the fine uniform texture of anthracite; and at first glance might readily be mistaken for it. It is, hovever, much softer and more brittle. The percentage of ash is very much less than in any other Iowa or Missouri coals, and in other respects it may be regarded as the best grade found in either of the two states mentioned. These factors are suggestive that in the formation of certain coals, and especially those having the physical characters of anthracite, the original conditions of deposition may have played a more important part than has been generally supposed, and that the origin of the materials was quite different from that for many of the ordinary bituminous kinds.

The implication that in the case of anthracite the coal-forming materials were almost entirely changed about the time of, or soon after, deposition, because of the longer exposure to atmospheric influences than in the case of the bituminous varieties, practically precludes any subsequent alterations after the plant remains have been covered up by sediments. Few clastic rocks are not porous enough to permit of a more or less ready circulation of underground water. Moreover, crustal deformation, no matter how small it is, gives rise to changes of some sort in the character of the beds effected. Mineralogical alterations in the mineral constituents are thus ever going on in the rocks. Indeed, the whole mineralogical composition and structure of stony aggregates are being modified continually; in some places slowly, in others more rapidly, according to the attending circumstances. The ever changing physical conditions invariably set up continuous molecular shiftings in every rock, no matter what its composition or what its relations.

It has been said that the changes undergone by rock masses have been occasioned by the natural tendencies of minerals to assume combinations more stable from those less stable. But the statement has not carried with it the full import and meaning that it should; for in any particular case, while there is an attempt towards adjustment to satisfy a certain set of conditions, the conditions themselves are continually changing, sometimes in one direction, sometimes in another. In the production of these alterations in rock masses time does not necessarily enter as a factor, although ordinarily the older a rock is the greater is the chance for disguising its primitive character.

The very nature of the hydrocarbons calls for a constant elimination, though at an ever decreasing rate, perhaps, of these compounds from the old vegetal accumulations. In regions affected by orogenic movements there would be commonly a considerable acceleration of the process: and with the Pennsylvania anthracite, mountain-making forces must certainly have played an important role in hastening the change. But in comparing the effects of tangential pressure upon coal beds and their associated strata in different parts of a field, many factors enter into consideration which involve great difficulties and require the most detailed examinations.

EDITORIAL COMMENT.

THE U. S. GEOLOGICAL SURVEY.

Major Powell has resigned the directorship of the Geological Survey of the United States, and it is understood that the office will be tendered to Mr. C. D. Walcott, who has for many years held the position of palæontologist and lately chief geologist of the survey. We trust that this change will augur the reorganization of the work on efficient and economical footing and that the survey will, under Mr. Walcott's management, stand as high in the esteem of the scientific world and the general public as befits so important a department of the government.

THE COLUMBIAN EXPOSITION.

Gems, Native Metals, and other Rare Minerals.

The mineralogical collections on exhibition in the various departments of the World's Fair deserved, on the whole, a great deal of praise: but it was to be regretted that in some of the sections the arrangement was very unsystematic and the labeling often incorrect. If one were to attempt a review of each departmental exhibit, the work would assume vast proportions. The displays were not entirely confined to the Mines and Mining building, as might be naturally expected, but many were also in the other buildings. Even exhibits of the same character and by the same country or state were occasionally divided and housed in two or more buildings, in some instances quite a mile apart. The subject of mineralogy as here treated, being, perhaps, more scientific than economic, received only secondary consideration in the general plans for the exhibits in the Mines and Mining building; but it was, perhaps, better to display mainly the natural economic resources of the countries represented. Thus we found a large part of the first or ground floor of this building occupied chiefly with collections of ores and illustrations of the processes of mining and metallurgy. Almost every state and country had one or more collections of minerals, some of which were arranged very systematically, but many of these were limited to purely economic exhibits.

One of the most interesting collections was that exhibited by Mr. George F. Kunz, of New York, in the west gallery, representing the minerals occurring on Manhattan island, the site of New York city. Among the gems in this collection were beryl, garnet, moonstone, tourmaline in various colors, some good zeolites, specimens of epidote, cyanite, molybdenite, etc. Mr. Kunz also exhibited his well known collection of meteorites.

In the same west gallery was a collection of brilliant quartz crystals, containing inclusions of anthracite, water, carbonic dioxide, etc., from Middleville, N. Y. There were also excellent exhibits by Messrs. English, Ward, Howell, and other dealers in minerals; and by the states of Colorado, Nevada, New York, and Ohio.

It was surprising to see the great number of collections of gems. Diamonds, both cut and rough, were exhibited by New South Wales from several localities; but the best were from the Bingera district, exhibited by Prof. Liversidge, F. R. S. Other diamond exhibits were by Brazil, North Carolina, and Cape Colony, the latter very extensive and showing the various operations of diamond mining. New South Wales showed the diamantiferous sand, and Cape Colony the so-called blue earth.

North Carolina exhibited a large variety of gems, including ruby, sapphire, emerald, hiddenite, garnet and beryl. Mr. J. A. D. Stevenson, of Statesville, N. C., to whom is attributed the discovery of many localities of choice minerals and who lives only a few miles from the celebrated hiddenite locality, had an attractive collection of gems in this state's section.

Idaho showed a good collection of gems from Hailey, some sapphires from Stanley Basin, small rubies in sand from Huy's Placer, and rather an extensive collection of rough opal from Owyhee county. Some of the opals were of large size and must weigh thirty to forty carats.

Utah and New Mexico also exhibited opal: and Utah had fine specimens of topaz. Magnificent specimens of turquoise from Los Cerrillos were seen in the New Mexico section, and in the Colorado section small specimens from Villa Grove.

Montana had garnets, sapphires, and rubies which exhibited considerable brilliancy.

Massachusetts and other eastern states had exhibits of cut and rough gems. Some noticeable ones were from Fitchburg, Mass. (beryl and tourmaline), and from South Paris, Maine.

Montana and Colorado had unquestionably the most valuable displays of native gold; and the former state exhibited a beautiful collection of crystallized gold, showing most of its known forms. Nevada had interesting specimens of native gold in quartz, in iron ore, in calcite, etc., and a handsome specimen of gold wire disseminated through gold quartz. The Argentine Republic had good nuggets from Chubut, and Ecuador a specimen of quartz entirely covered with native gold. New South Wales, Canada, Brazil, and other countries, also contributed gold specimens. One large specimen in quartz from New South Wales was valued at over £1,200. This country also displayed a large number of gold crystals, some of them having good octahedral forms. In the west gallery was seen the original gold discovered by Marshall at Sutter's Mill, California, in 1848, which caused the "gold fever of '49."

Mexico exhibited native silver from Chihuahua, Zacatecas, Guanajuato, and other states, some of the specimens weighing several hundred pounds. Argentine had native silver from La Rivja and other provinces, and a strange form of native silver and nickel. Idaho and Montana showed small quantities, and the latter state had wire silver disseminated through calcite, etc. Montana displayed native silver from Elkhorn and other localities, including a particularly noticeable specimen of wire silver from the Butte and Boston mine.

Michigan exhibited the largest collection of native copper, both crystalline and massive, some masses weighing several tons. Montana also had native copper, principally from Butte.

Spain showed a fine collection of cinnabar, native mercury, and associated rocks, from Almaden. Mexico had this mercury sulphide from Guerrero, San Luis Potosi, etc.; Nevada, from the Washoe district; and Russia, from the southern provinces.

Canada showed the exceedingly rare platinum arsenide, sperrylite,* from the Vermillion mine of the Canadian Copper Company, which placed over one hundred grammes of this mineral on exhibition. New South Wales had platiniferous river sand and a small specimen of iridium. This country also gave the best exhibit of native bismuth and of bismutite, the carbonate. A nugget of platinum weighing over 150 ounces was displayed in the Great Britain section, being exhibited by the celebrated firm, the Johnson-Matthey Co., of London. This firm also exhibited other rare elements, iridium, palladium, rhodium, osmium, etc.

Pennsylvania exhibited beautiful radiating needle crystals of millerite (NiS), and massive pyrrhotite ($Fe_{11}S_{12}$) containing 2 to 5 per cent. of nickel, from the Gap mine, Lancaster county. Canada had a large display of nickeliferous pyrrhotite and associated minerals, from Sudbury; also specimens of niccolite ($NiAs$) and of gersdorffite ($NiAsS$). Oregon had beautiful specimens of garnierite,† a hydrous nickel magnesium silicate, containing 20 to 30 per cent. of nickel, from the Excelsior district, Douglass county. This mineral from New Caledonia was exhibited in the New South Wales section, together with noumeaite and asbolite.

Pennsylvania also showed calamine‡ ($H_2Zn_2SiO_5+Fe_2O_3$), sphalerite (ZnS), and their associations, from the famous Friedensville mines. Wisconsin displayed a large quantity of zinc minerals, the principal being smithsonite ($ZnCo_3$), a most unattractive looking mineral. Missouri had beautiful specimens of crystallized and massive sphalerite, calamine, and smithsonite. New Jersey exhibited a fairly good collection of zinc minerals, including the beautiful zincite (ZnO), with its gorgeous coloring, associated with franklinite ($Fe_2O_3 + ZnOMnO$), and botryoidal smithsonite and calamine, all from Sussex county. But the zinc minerals, like those of lead, copper and iron, are so widely distributed throughout the country that nearly every exhibit contained many specimens, making it difficult to select the best and typical specimens in each section.

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*H. L. Wells, and S. L. Penfield, Am. Jour. Sci., III, vol. xxxvii, pp. 67-73, Jan., 1889.

†F. W. Clarke, Am. Jour. Sci., III, vol. xxxv, pp. 483-488, June, 1888.

‡J. Eyerman, Am. Jour. Sci., III, vol. xxxvii, p. 501, June, 1889.

Spain had an unique specimen of galenite, a cube containing fully 60 cubic feet.

Arizona displayed a very large block of the beautiful azurite, surmounting a base of malachite; some fine specimens of chrysocolla, the copper silicate, associated with wad; magnificent specimens of the beautiful minerals, vanadinite and descloizite; and some of the rarer lead and silver minerals, for which this state is now famous.

Japan had a good collection of stibnite (Sb_2S_3), some very large and fairly well crystallized, but none equal, either in size or form, to some from the same localities now in our American collections. Native antimony was also exhibited. Nevada, and other western states, Canada, and New South Wales, also displayed native antimony and stibnite, and the latter country, auriferous stibnite.

Cassiterite was exhibited from New South Wales, Mexico, South Dakota, and Wyoming. Orpiment and realgar were exhibited from Oregon.

Large and well terminated quartz crystals were shown in the Japanese section; one beautiful specimen with perfect terminations, from Kimpozan Kai, being nearly 40 cm. long, another about 18 cm. thick and over 65 cm. in length.

Great Britain had a large collection of economic minerals, well arranged. Canada had a large number of collections of silicates, oxides, carbonates, sulphides, etc., representative not only of her own domain, but also of foreign countries, which allowed comparisons.

Brazil had three small collections; Argentine, several, representing principally the copper and lead minerals and associates.

New South Wales had a large collection, numbering many hundred specimens, representative of most of the known groups, besides a few specimens of meteorites. Indeed, this section was unquestionably the largest and best exhibit in the Mines and Mining building.

While the mineralogy of the United States was very successfully displayed, it should have been more thoroughly representative. Too much poor material was exhibited, and this may perhaps have been due to the fact that the governors or commissions of several of the states did not exercise good judgment in selecting representatives for the department of scientific mineralogy.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On the sedimentary origin of iron ore deposits and itabirite (*Eisenglimmerschiefer*). J. H. L. VOGT, Salten og Ranen, Kristiania, 1891, pp. 214–224. (Translated from the Zeitschrift für praktische Geologie, January, 1894, pp. 30–35, by H. V. Winchell.)

"Salten og Ranen" appeared in 1891 as the first part of a geological description of the Norwegian province of Nordland, especially treating of the marble beds and ore deposits (iron ore, pyrite and chalcopyrite, argentiferous copper ores, galena, etc.).

The Tromsoe mica-marble group is always characterized by thick and extensive inclusions or interbedded deposits of iron ore (partly itabirite), which sustain a close relation with the immense limestone beds, and in the district examined by the author appear usually as separate strata immediately below the limestone, but sometimes contained in it.

At Naeverhaugen the ore deposit, consisting of hematite, quartz, etc., in fine alternating layers, can be followed continuously for a distance of five miles. The thickness is variable, from 18 inches to 50 feet. Above it limestone sometimes occurs immediately; sometimes there is a layer eighteen inches to three feet thick of "Skarnberg" schist. In the vicinity of the Naeverhaugen area the ore bed forms a peculiar, sharp S-curve, which reveals itself only by an overlap-fault, in the direction of the strike.

The belt of itabirite in Ranen has a length of from twenty to twenty-five miles. In Dunderlandsthal we meet two immensely thick limestone strata, corresponding to each other in every respect, each of which is a limb of an anticlinal fold and has below it the bed of itabirite. The thickness of the latter is here about sixty to seventy-five feet on the average; but at Kvitinge, where in other respects the stratum is lean, it is no less than 290 to 330 feet in thickness.

There is also almost complete correspondence between the two iron ore strata at Naeverhaugen and those at Ranen. In both regions we find principally hematite ($Fe_2 O_3$). In Dunderlandsthal it is developed as the specular or micaceous variety, and there is but little magnetite; then quartz, with some hornblende, biotite, garnet, epidote, feldspar, very little calcite, titanite, etc.; added to all of which is a mingling of apatite, amounting to about 1 per cent. on the average; very little sulphur and titanium; less than 1 per cent. of manganese; even the slag-forming elements (SiO_2, Al_2O_3, CaO, MgO, etc.) agree almost perfectly in thin section.

The ore-bearing stratum consists of a series of layers varying widely in iron content,—from about 10 or 20 to 60 or 65 per cent. Single layers are occasionally so rich as to be exploited, but as a whole the stratum must be considered, in most localities, rather poor in iron. Nevertheless the total content of iron (especially in Dunderlandsthal, where the itabirite has a greater development than at any other locality known in Europe) is of great importance and can only be compared with the iron mountains of northern Sweden, Gellivara, Kirunavara, etc.

The Cambrian (?) iron ores of Nordland find their closest analogy in Sweden with the so-called "Torrsten" ores ("Trockenerz," *i. e.*, ore which gives a dry or siliceous slag on being smelted). Both these ores are accompanied by a superabundance of quartz and acid silicates; but by very small amounts of carbonates and basic silicates. In both cases there is usually considerable apatite, very little sulphur, comparatively little manganese, and very much hematite in proportion to the magnetite. In fine, the "Torrsten" ores are distinguished from the other Archean iron ores by appearing more like normal strata and less like short lens-shaped masses.

The "Torrsten" ores are also related to the other iron ores in central Sweden belonging to the same general division. We thus arrive at the conclusion that the Swedish iron ores of the Dannemora–Persberg Norberg–Grängesberg type, belonging to the Archean formation, as well as the Norwegian ores of the Arendal–Krageroe type, were formed in the same manner as the apparently Cambrian ores of the Naeverhaugen-Dunderlandsthal type.*

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*Besides this class of iron ores, the following are represented in Scandinavia: 1. Iron ores formed by pneumatolytic processes; 2. Segregations in basic eruptive rocks; also, the ore deposits of the Gellivara–Kirunavara type, which are not associated with limestone and do not correspond with the Dannemora-Persberg-Arendal-Naeverhaugen type in that respect. For this reason no attention is paid here to the iron ores of northern Sweden, nor to the ores occurring in the "tiefen Urgneiss" of Norway.

It is by Swedes and Americans, and partly also by German investigators, that it has been shown that the extensive iron ores of the Cambrian and upper part of the Archean are of sedimentary origin. This conclusion rests upon the following facts:

1. The ores are always parallel with the bedding and participate in all folds and flexures. A general strike contrary to that of the rocks has not been proven.

2. The ore deposits are bedded in a typical manner, consisting principally of a series of abruptly changing layers, chemically and mineralogically in strong contrast.

3. Each single rock series, or each stratigraphic horizon, is characterized by a definite type of iron ore bed.

4. The ore deposits occur in close connection with beds of limestone and dolomite, which are of rare occurrence, especially in the Archean.

5. They form a limited class, well characterized mineralogically, and still better chemically, by the metal-combination Fe and Mn, which can be sharply distinguished from the group of ore deposits formed by processes of emanation (containing chiefly Cu, Ni, Co, Zn, Pb, Ag, Sn, Fe, etc.).

6. One definite class of iron ore deposits, viz., the basic and at the same time manganiferous ore, is often marked by the presence of graphite or organic matter; and in some Archean ore deposits of the United States we even find a combination of siderite and carbon or organic matter, corresponding to the "Kohleneisenstein" or blackband ironstone.

7. In all the younger formations undoubtedly sedimentary iron ore deposits occur (e. g. meadow, lake, and bog ore, at the present time; oolitic iron ore, of the Jurassic; blackband ironstone, in the Carboniferous). *A priori* we should expect to find corresponding deposits in the oldest sediments.

8. In conclusion, it may also be mentioned that this class of iron ore deposits, unlike the majority of other ore deposits, has no direct connection with any eruptive rock.

That these iron ores cannot be supposed to be intrusive eruptive sheets needs no further proof. It may be attempted to prove that the ores under discussion were formed by pneumatolytic processes. As the most important support for this theory, it must be shown that our ores, mineralogically as well as structurally, are distinguished partly by the identical mineral combinations (garnet, epidote, different augites, and vesuvianite and scapolite, as exceptions), which would be produced in the limestone and calciferous schists by contact metamorphism, as well as by metamorphism accompanied by pneumatolytic processes. It may however be mentioned that the latter minerals belong to almost any primary limestone, whether it be accompanied by iron ore beds or not. That is, the minerals are formed not only as a result of that special contact metamorphism, but also as a result of that general metamorphism which the Archean formations have undergone. Furthermore, that very siliceous mineral, viz., quartz, which is most abundant in our iron ores, does not belong to the group of minerals formed by contact metamorphism in limestones and calcitic schists. The formation by pneumatolytic processes would conflict sharply with the characteristics mentioned under 2, 3, 5 and 6; and would not explain those under 1, 4, 7, and 8.

That our iron ores cannot be ascribed to metasomatic action (e. g., by the percolation of $FeCO_3$ solutions through limestone, by which $CaCO_3$ is dissolved and $FeCO_3$ deposited) is explained in detail in the original work, pp. 137, 138.

The numerous different phenomena of these ores differ widely, it is true, but still the following series of general criteria can be deduced, to which a genetic significance may be ascribed.

1. The iron ore beds appear most frequently, although not always, together with or in the immediate vicinity of limestone or dolomite. In individual instances (Nordland, for example), it can be shown that the iron ore was formed at an earlier epoch than the accompanying limestone or dolomite.

2. In spite of this intimate association, the iron ores (magnetite and hematite) occur only sparingly in the limestone or dolomite, but are much more commonly mingled with quartz, or rather with acidic silicates.

3. Mingled with the iron ores there is nearly always some manganese, while, on the other hand, Cu, Pb, Zn, Ni, Co, As, Sb, Bi, etc., occur only sporadically, or are entirely wanting; very little TiO_2 and Si; but occasionally some native gold.

4. Apatite and other phosphatic minerals are present in varying amount, on the whole somewhat more abundant than in the neighboring schists and limestones.

Because of the intimate connection between our iron ores and the limestone and dolomite beds, and further because of the analogy between the Archean and Cambrian magnetite and hematite beds, on the one hand, and the siderite, pyrolusite, and hematite deposits of the younger formations, besides the recent lake and bog ores, on the other hand, the conclusion is reached that *our ores were formed by precipitation from solutions of ferrous carbonate.* We may state in advance that these carbonated solutions in earlier times, as at present, have arisen principally through the destruction of rocks already in existence. $FeCO_3$ shows, as is well known, a strong tendency toward higher oxidation, for example, through the oxygen dissolved in water. The separation of $FeCO$ can thus only take place when oxidation is hindered or prevented by carbon or organisms. That the iron was precipitated directly as *oxide*, hydrous or anhydrous, in the Archean and Cambrian deposits, in the same manner as in recent lake ores, is shown by the fact that we often meet beds of iron ore wholly free from lime and magnesia, on the one hand, and of limestone and dolomite almost wholly free from iron, on the other, sharply distinct from each other and yet intimately intermingled, and these contain in most cases no trace of organic matter which could have prevented the oxidation. Only in rare instances corresponding to the blackband ironstone (e. g. in Archean deposits of siderite mingled with carbon, and in some Swedish "Blandstenar," i. e. manganiferous iron ores mingled with carbonates and in many cases also with organic matter) can we establish the probability of an original separation as carbonate of iron.

By oxidation according to the formula, $2FeCO_3+O=Fe_2O_3+2CO_2$, free carbonic oxide is produced. By this:

(*a*) The separation of $CaCO_3$ (and $MgCO_3$), and at the same time of Fe_2O_3, is hindered.

(*b*) The precipitation of silica is facilitated.

(*c*) The phosphoric acid present in the solution is wholly or partly thrown down, if iron oxide (or hydrate) is suspended in the water.

(*d*) Manganous carbonate is not so quickly oxidized as the corresponding salt of iron. Hence the principal part of the manganese will be thrown down at a later period, depending on the local conditions, as oxide (hyperoxide), hydrous oxide, or carbonate (together with some of the CaCO and $MgCO_3$).

That the precipitations must actually occur in the order given,—viz., first, oxide of iron, with silica and phosphoric acid, together with part of the manganese; next, the bulk of the manganese; and finally, calcium and magnesium carbonates,—is proven by many concordant observations regarding the deposits of hot springs, salt wells, etc.

For the sake of comparison it may be said that the lake and bog ores, which owe their origin chiefly to separation by the oxidation of carbonated solutions, really consist of hydrated iron oxides, with considerable silica and P_2O_5, but on the other hand with very little carbonate, manganese in increasingly greater proportion, and occasionally traces of TiO_2, Cu, Ni, Co, Zn, As, etc. Moreover, at the bottom of the ocean have been found manganese concretions, comparable to the lake ores, and probably formed by analogous processes.

Those chemical reactions which follow as a direct result of the oxidation of ferrous (and manganous) carbonates explain why

(1) The Archean and Cambrian magnetite and hematite (in the United States also siderite) deposits occur in close relation with limestone (and dolomite).

(2) The precipitation of the iron ore-limestone-dolomite series was always in many places accompanied by the separation of the iron ore beds.

(3) The iron ore, although occurring so often in and near limestone (or dolomite), nevertheless is not mingled principally with carbonates but with silicates, especially quartz and acidic silicates. The silica which was separated at the same time with some of the alumina, lime, magnesia, etc., was precipitated under the same conditions as the silicates present in the granular limestone, and later underwent the same metamorphism; hence the mineralogical and structural analogy.

(4) The iron ores almost always contain some manganese, partly in proportionately significant amount, while Cu, Pb, Zn, Ni, Co, etc., are almost wholly absent.

(5) We occasionally find in one and the same locality (Långban, Nordmarken) separated independent beds (a) of siliceous and (b) of

manganese ore, poor in iron oxide but rich in $CaCO_3$ and $MgCO_3$. It also explains why the limestones and dolomites adjoining the ore are on the whole richer in manganese and poorer in iron than the iron ores.

(6) These iron ores, like the recent lake and bog ores, are marked as a whole, though with numerous exceptions, by a larger apatite or phosphorus content than the associated schists and limestones.

(7) Of the rare elements, it is singular that gold alone in the native state is occasionally found in a relatively large amount in the iron ore (e. g. in the itabirite in Brazil, Carolina, Africa, and Sweden). This is easily explained by the reducing action of ferrous carbonate (instead of the sulphate as in the metallurgical practice) upon $AuCl_3$. *Analogy*: Native gold is frequently found in stalactites of manganese ore in Australia.

(8) Finally, it may be remarked that the lenticular shape of our magnetite and hematite deposits is explained by their analogy with the irregularly shaped beds of lake ore in relatively deep lakes.

The sedimentary iron ore deposits occurring in Sweden and Norway may be divided into a series of sub-groups (with the Swedish names): "Torrsten," "Quicksten" with "Enbårt gående," "Blandsten," and "Manganmalme," which are distinguished in the order named by (a) a decrease in the silica content and an increase in the content of basic silicates and carbonates, as regards their slag-producing constituents. We also find, in general, (b) an increase of manganese, and (c) a decrease of apatite content.

The chemical evidence is repeated so often that we must ascribe to it a theoretical significance. It apparently sustains the most intimate relation with the details of the succession of precipitates. Under normal processes of oxidation ($2FeCO_3 + O$), Fe_2O_3, with relatively large amounts of SiO_2 and P_2O_5 but with very little Mn, is separated, and there may thus result a "Torrsten" even out of a solution rich in Mn. On the other hand, where, for any reason whatever (e. g. by the presence of organic matter), oxidation is prevented or delayed and precipitation can only be accomplished by the aid of an excess of carbonic acid, we have contemporaneous deposition of iron, of a large part of the Mn content, and also of some lime (and magnesia) carbonate. We obtain thus a manganiferous iron ore mingled with carbonates and basic silicates. *Analogy:* the primarily formed siderite deposits of the later formations are distinguished by a relatively larger Mn content than the primary limonite and hematite deposits in the same formations.

The Twenty-First Annual Report of the Geological and Natural History Survey of Minnesota, for the year 1892. 8vo, 171 pages; Minneapolis, 1893. The report is divided into seven parts, as follows: I. Summary statement and comparative nomenclature, by the state geologist, N. H. Winchell. Accompanying this is a table of pre-Silurian rocks of Minnesota with their equivalents in adjacent territory. This table will be of value in giving a concise statement of the nomenclature used by the Minnesota survey, and in showing the harmony and lack of harmony that exist in the naming and correlation of the older rocks of the Lake Superior region. II. The geology of Kekequabic lake in northeastern Minnesota, with special reference to an augite soda-granite, by U. S. Grant. This gives a geological description of a limited area and a petrographical description of the eruptive rocks, the most important of which are an augite-soda-granite and a hornblende-porphyrite. III. Catalogue of rock specimens collected in northeastern Minnesota in 1892, by U. S. Grant. IV. Preliminary report of a reconnoissance in northwestern Minnesota in 1892, by J. E. Todd. Here are given notes of a summer's work on the glacial geology and topography of the northwestern part of the state. No exposures of rocks older than the drift were seen except where the Archean outcrops on the south shore of the Lake of the Woods. V. Field observations of N. H. Winchell in 1892. This contains: notes on the Mesabi iron range; manganese oxide at Monticello; Republic and Ishpeming, Mich.; Potsdam, N. Y.; Morrison county, Minn.; some problems of the Mesabi iron ore;* and remarks on the so-called muscovadyte or muscovado rock. A number of pages is given to a review of the question of the first recognition of the unconformity between the two great iron-bearing formations (Upper and Lower Huronian) in the lake Superior region, and especially in the Marquette district; the author thinks that he was the first to recognize this break and to appreciate its importance, and that Prof. R. D. Irving did not recognize it. In his notes on the Potsdam region Prof. Winchell seems inclined to put the true Potsdam sandstone where it is usually placed by geologists, at the base of the Upper Cambrian, and not at the base of the Lower Cambrian where he has heretofore insisted that it belonged. He thus no longer regards the Sioux quartzite and the quartzite at the base of the Animikie as the western equivalents of the Potsdam of New York. VI. Additional rock samples collected in 1892, to illustrate the notes of N. H. Winchell. VII. Additions to the library since the report for 1891. G.

The Trap Dikes of the Lake Champlain Region. By J. F. Kemp and V. F. Marsters. U. S. Geol. Survey, Bulletin 107; 62 pages, 4 plates, 1893. In the vicinity of lake Champlain, and especially abundant along the shores of the middle part of the lake, are numerous dikes of light colored acid rocks, feldspathic porphyries or trachytes (bostonites), and darker basic ones. The latter include diabases, camptonites, monchiquites and fourchites. The diabase dikes are very numerous in the older rocks on the west side of the lake and frequently cut the iron ore bodies; they pass into camptonites, which are also quite common. The monchiquite and fourchite dikes are not so plentiful, of the latter only one being known. A petrographical description of each of these rock types is given and there are some remarks on the classification of dike rocks, the following divisions of the more basic dike rocks being made: A. Syenitic lamprophyres, including (1) minettes and (2) vogesites; B. Dioritic lamprophyres, including (1) kersantites, (2) camptonites and (3) diabases; C. Monchiquites; D. Fourchites. All the strata of the shores of lake Champlain, up to and including the Utica slate, are cut by these dikes, and since their intrusion they have suffered practically no deformation. From the fact that camptonites, monchiquites and fourchites are almost invariably associated with eleolite syenite, the authors think that this rock may perhaps be found in the Adirondacks, or that possibly these dikes represent the extreme southern manifestation of the eruptive action that produced the nepheline rocks near Montreal, whose time of intrusion was between the Trenton and Lower Helderberg. G.

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*Already published in the American Geologist, vol, x, pp. 169-179, Sept., 1892.

The Granite at Mounts Adam and Eve, Warwick, Orange Co., N. Y., and its contact phenomena. By J. F. KEMP and ARTHUR HOLLICK. Annals N. Y. Acad. Sci., vol. 7, pp. 638-654, pls. 2 and 3, 1894. The granite is of a basic hornblendic type, almost a quartz diorite; it has intruded the white limestone; and at the junction of the two is a well developed contact zone with minerals peculiar to granite-limestone contacts elsewhere. On approaching the limestone the granite becomes richer in pyroxene (malacolite) and at the contact is a distinct scapolite zone, beyond which the limestone is charged with aggregates of silicates. The two limestones (white and blue) are regarded by the authors as probably one, the former being a more metamorphosed phase of the latter. The same opinion is held by F. L. Nason for the southward extenson of these limestones in New Jersey, where the blue is found to be of Cambrian age. The paper is accompanied by a "List and Bibliography of the Minerals occurring in Warwick township," by Heinrich Ries. G.

On the Crystallization of Herderite. By S. L. PENFIELD. Amer. Jour. Sci., 3, vol. 47, pp. 329-339. pl. 8, May, 1894. An examination of some specimens from Paris, Me., which proved to be monoclinic, led to a study of specimens from other localities with the result that herderite was found to be always monoclinic and not orthorhombic as hitherto thought. In this mineral fluorine and hydroxyl are isomorphous and occur in different proportions; some of the physical properties of herderite vary as the amount of hydroxyl increases or diminishes. G.

On the Chemical Composition and Related Physical Properties of Topaz. By S. L. PENFIELD and J. C. MINOR, JR. Amer. Jour. Sci., 3, vol. 47, pp. 387-396, May, 1894. Topaz is found to contain a small and variable percentage of hydroxyl which is isomorphous with and partly replaces the flourine. As the proportion of these two substances vary there is found to be a decided change in some of the physical properties of the mineral; thus, as the proportion of hydroxyl increases the specific gravity, the strength of the double refraction, the divergence of the optic axes and the length of the crystallographic axes *a* and *c* decrease, while the indices of refraction increase. G.

Devonische Versteinerungen von Lagoinha in Matto Grosso (Brasilien); by LUDW. VON AMMON. (Zeitschr. der Gesellsch. für Erdkunde zu Berlin, vol. XXVIII, 1894.)

These descriptions are based upon fossils collected by Vogel in the region from which Herbert Smith obtained the material described by Orville Derby in 1890. The locality is upon the Chapada-plateau, in the Taquarassú region, about 40 miles east of Cuyaba, capital of the state of Matto Grosso; the rock principally a yellowish or rusty brown sandstone (like most of the fossil-bearing Devonian strata of South America), with intercalated clay shales. The following fauna is described:

Harpes sp.
Phacops braziliensis Clarke.
Bellerophon chapadensis, nov.
Tentaculites bellulus Hall.
Orbiculoidea baini Sharpe.
Chonetes falklandica Morris and Sharpe.
Spirifer vogeli, nov. (cf. *duodenarius* Hall),
Leptocœlia flabellites Conrad.

Derby correlated the fauna on the basis of species identified by him with the middle Devonian or Ereré fauna of the Amazonas, but v. Ammon finds in it a closer similarity with the lower Devonian or Maecuru fauna of that region.

Duslia, eine neue Chitonidengattung aus dem böhmischen Untersilur, nebst einigen Bemerkungen über die gattung Triopus Barr. By J. J. JAHN. (Sitzungsber. der kais. Akad. der Wissensch. in Wien, Dec., 1893.)

Duslia is a genus founded upon entire individuals strikingly similar in certain structural features to some of the recent Chitons, while all other of the older paleozoic remains which have been referred to the genus *Chiton* are more widely dissimilar from typical forms of that genus. The author regards Barrande's genus *Triopus*, described as a trilobite, also one of the *Chitonidæ*.

Notes Paléontologiques; I. Crustacés. By J. BERGERON (Bull. de la Soc. Géol. de France, 3d ser. vol. XXI, pp. 333-347, pls. VII, VIII). In this paper the writer gives a precise account of his trilobite genus *Asaphelina*. which is an asaphid from the Arenig horizon, principally characterized by a pair of long pygidial spines. Further, the species *Anthracopeltis crepini* Boulay, from the coal measures of Bully-Grenay, is redescribed with figures, and shown to be a *Prestwichia*.

The Appendages of the Pygidium of Triarthrus. By C. E. BEECHER. (American Journal of Science, April, 1894, pp. 298-300, pl. VII.) The author continues his elucidation of the ventral anatomy of the Trilobite by demonstrating that the endopodite and exopodite of the thoracic legs, which are adapted respectively to crawling and swimming (see AM. GEOLOGIST, January, 1894) become progressively modified posteriorly, and upon reaching the pygidium the proximal segments of the endopodite become greatly expanded, forming a paddle-like organ, whose form implies a modification of function, from crawling to swimming. The form of the pygidial exopodite is modified only in the greater development of the fin-like and fimbriated basal joint.

Revision der ostbaltischen silurischen Trilobiten. Abtheilung IV; Calymmeniden, Proetiden, Bronteiden, Harpediden, Trinucleiden, Remapleuriden, und Agnostiden. By FRIEDRICH SCHMIDT. (Mem. de l' Acad. Imp. des Sci.

de St. Petersb., 7th ser., vol. XLII, No. 5, pp. 93, pl. 1–6, 1894.) This continuation of the author's elaborate study of the Silurian trilobitic faunas of Russia embraces the consideration of 38 species and varieties of 13 genera and subgenera belonging to the families mentioned. Fourteen of the species and varieties are new. A precise redefinition of the genus *Calymmene* (the author follows Lindström in the adoption of the double *m*) restricts it to forms with rounded genal angles, cephalic margin without serrations, glabella reaching the anterior border and bearing 3–5 pairs of lobes, thoracic pleuræ with triangular articulating surfaces, pygidial pleuræ 5 on each side (type, *C. tuberculata* Brûnnich). This limitation of the genus opens the way for the employment of Corda's term *Pharostoma* for a subgeneric division, to include species having the genal extremities produced into spines, border of the glabella toothed, glabella short, not reaching the anterior border and with 2 pairs of low lobes on each side, dorsal furrows with a pit at each anterior extremity and a subcircular expansion behind, and thoracic pleuræ without triangular articulating surfaces. A single new term is introduced in a similar capacity, that is, as a subgenus of *Calymmene*, viz.: *Ptychometopus*, for the species *C. volborthi*, nov., which is characterized by elevated ridges extending along the anterior facial sutures to the anterior submarginal groove. Of the species described 6 belong to *Calymmene*, 3 to *Pharostoma*, 1 to *Ptychometopus*, 3 to *Bronteus*, 8 to *Proetus*, 2 to *Cyphaspis*, 1 to *Menocephalus*, 1 to *Harpides*, 2 to *Harpes*, 1 to *Trinucleus*, 5 to *Ampyx*, 3 to *Remopleurides*, and 1 to *Agnostus*.

Geological Survey of Canada, Annual Report (new series), vol. V, for 1890-'91. ALFRED R. C. SELWYN, C. M. G., Director. Two parts, containing thirteen reports; pp. xlvi, 1521, with 58 plates (34 being maps, sections and views; and 24 statistical diagrams of the mineral resources of Canada). Ottawa, 1893. In this very comprehensive yearly report much varied information is presented, concerning the geology, topography and natural resources of various parts of British America in which special explorations have been in progress. The summary reports of the work of the survey during 1890 and 1891, by the director, occupy 178 pages.

Mr. R. G. MCCONNELL next has a report of 67 pages on the portion of the District of Athabasca between the Peace and Athabasca rivers north of Lesser Slave lake. Devonian limestones on these rivers dip prevailingly three or four feet per mile northward, and are apparently succeeded conformably by the Cretaceous series. The vast interval of time between these periods is, so far as observed, unrepresented, either by deposition or erosion, from which the area is thought to have been during all that time the bed of an abyssal ocean, too far from its shores to receive appreciable sediments. The Cretaceous section ranges from the Dakota up to the Laramie, the former being represented by the peculiar Tar sands, 140 to 225 feet thick, which have become saturated with bituminous matter rising from somewhat deeply underlying Devonian strata. "The Tar sands evidence an upwelling of petroleum to the surface unequaled elsewhere in the world, but the more volatile and valuable constituents of the oil have long since disappeared, and the rocks from which it issued are probably exhausted as the flow has ceased."

Mr. J. B. TYRRELL contributes a memoir of 235 pages, on northwestern Manitoba and portions of the adjacent Districts of Assiniboia and Saskatchewan. During the Tertiary era great denudation of the Cretaceous strata of that region was forming the present valleys of the Saskatchewan, Red Deer, Swan, Valley, and Assiniboine rivers, and the broad lowland plain which holds in its extensive but shallow depressions lakes Winnipeg, Manitoba, and Winnepegosis. From this plain of the great Manitoba lakes the Cretaceous rocks were almost entirely denuded down to the underlying floor of Paleozoic limestones. The main stream of the river system effecting this erosion appears to have flowed northwesterly through Manitoba. Farther north it probably traversed the present areas of Hudson bay and strait, having belonged to a time of gradual uplift of the continent much above its present hight, preceding and finally producing the Ice age. The observations of glacial striæ show that the ice-sheet flowed southward across the high Assiniboia plains, and southeastward over the Manitoba lake district. Till thinly covers the Paleozoic rocks of that district: but it is thicker, and is frequently accompanied by overlying beds of modified drift upon the vast plateau of Cretaceous shales on the west.

The report of Dr. ROBERT BELL, on the Sudbury mining district, occupies 95 pages, including four appendixes. The accompanying map is sheet 130 of the Ontario series of the Survey, covering 72 miles from east to west by 48 miles from north to south, and comprising the nickel deposits which have become so celebrated during the last few years. The rocks are successively of Laurentian, Huronian, and probably Lower Cambrian age, with large areas of pyritiferous greenstones in the Huronian series. The ores of nickel are always found in association with pyrrhotite, which forms brecciated masses in the greenstones or at their contact with other rocks. The average amount of nickel in this iron sulphide is only two to three per cent., but richer ores are found in small quantities. Dr. Bell considers that the nickeliferous pyrrhotite has resulted from a state of fusion. Among other economic minerals of the district, ores of copper, lead, zinc, and gold are enumerated.

Hunters' Island, a large Archean tract, almost completely surrounded by canoeable streams and lakes, adjoining the northern boundary of Minnesota, is described by the late Mr. W. H. C. SMITH. The gneisses and schists commonly present the topographic features of rounded hills and *roches moutonnées*, with plentiful drift. Courses of glacial striation range from S. 2° W. to S. 43° W.

Describing the southern portions of Portneuf, Quebec, and Montmorency counties, which reach from the watershed south of lake St. John to the St. Lawrence, Mr. A. P. LOW remarks the nearly due south course of all the glacial striæ on the comparatively low country north of that lake, which is 350 feet above the sea. Thence the ice-sheet carried Trenton limestone boulders up 1,100 feet in a distance of 20 miles southward on the Archean highlands. Approaching the St. Lawrence, the striation is found to be much influenced by minor topographic forms of valleys and hills. Till is spread over the whole region, covering to a greater or less thickness the rounded Archean hills; and only along the stream valleys is it concealed by gravels, sands and clays, of the modified drift and of later alluvial origin. The end of the Glacial period was attended by a depression of this part of the continent about 600 feet below its present elevation, as shown by terraces and deltas of fossiliferous stratified marine clays and sands, forming portions of the modified drift, which rest on the slopes of the till along the river valleys.

Other reports in this volume are by L. W. Bailey and W. McInnes, on the counties of Temiscouata and Rimouski, in the province of Quebec, and on adjoining areas in New Brunswick and Maine (28 pages); by Hugh Fletcher, on the counties of Pictou and Colchester, Nova Scotia (193 pages); by H. P. H. Brumell, on natural gas and petroleum in Ontario (94 pages); by G. C. Hoffman, on the chemical work of the survey (72 pages); and by E. D. Ingall, on mineral statistics and mines, for 1890 and 1891 (together 401 pages).

RECENT PUBLICATIONS.

I. *Government and State Reports.*

Annual Report of the Board of Regents of the Smithsonian Institution, 1891, contains: Some applications of physics and mathematics to geology, C. Chree; Origin of the rock pressure of natural gas in the Trenton limestone of Ohio and Indiana, Edward Orton; Geysers, W. H. Weed; The Gulf Stream, Alexander Agassiz; On the absolute measure of hardness, F. Auerbach; The flow of solids, or the behavior of solids under high pressure, Wm. Hallock.

Bulletin of the United States Geological Survey, No. 106. The Colorado formation and its invertebrate fauna, T. W. Stanton.

Geological Survey of Alabama: Report on the Coal Measures of Blount mountain, with map and sections, by A. M. Gibson. 8vo., pp. 1-80, 1893.

Iowa Geological Survey, vol. 2: Coal deposits of Iowa, by C. R. Keyes. 536 pages, 18 plates, 1894.

Eighteenth Annual Report of the State Geologist of Indiana, contains: Introductory, S. S. Gorby; Geology of Noble county, C. R. Dryer; Flora of Noble county, W. B. Van Gorder; Report upon the geology of Lagrange county, C. R. Dryer; The drift of the Wabash-Erie region, C. R. Dryer; Report of the inspector of mines, Thomas McQuade; Report of the state supervisor of oils, N. J. Hyde; Report of the state supervisor of natural gas, E. T. J. Jordan: Indiana's structural features as revealed by the drill, E. P. Cubberly: Paleontology, S. A. Miller: Natural gas and oil map.

Geological and Natural History Survey of Minnesota, 21st Ann. Rept., contains: Summary statement and comparative nomenclature (with a table of the Pre-Silurian rocks of Minnesota); The geology of Kekequabic lake in northeastern Minnesota, with special reference to an augite-soda granite, U. S. Grant: Catalogue of rock specimens collected in northeastern Minnesota in 1892, U. S. Grant: Preliminary report of a reconnoissance in northwestern Minnesota in 1892, J. E. Todd: Field observations of N. H. Winchell in 1892: Additional rock samples collected in 1892, to illustrate the report of N. H. Winchell.

II. Proceedings of Scientific Societies.

Bulletin of the Geological Society of America, vol. 5, pp. 71-514, contains: Evidences of the derivation of the kames, eskers, and moraines of the North American ice-sheet from its englacial drift, Warren Upham, pp. 71-86: The succession of the Pleistocene formations in the Mississippi and Nelson river basins, Warren Upham, pp. 87-100: Some recent discussions in geology, J. W. Dawson, pp. 101-116: Geological notes on some of the coasts and islands of Bering sea and vicinity, G. M. Dawson, pp. 117-146: Cenozoic geology along the Apalachicola river, W. H. Dall and J. Stanley-Brown, pp. 147-170; Paleozoic overlaps in Montgomery and Pulaski counties, Virginia, M. R. Campbell, pp. 171-190: Paleozoic intra-formational conglomerates, C. D. Walcott, pp. 191-198: Pleistocene distortions of the Atlantic seacoast, N. S. Shaler, pp. 199-202: Relation of mountain-growth to formation of continents, N. S. Shaler, pp. 203-206: Phenomena of beach and dune sands, N. S. Shaler, pp. 207-212: Gabbros of the western shore of lake Champlain, J. F. Kemp, pp. 213-224: Intrusive sandstone dikes in granite, Whitman Cross, pp. 225-230; Crustal adjustment in the upper Mississippi valley, C. R. Keyes, pp. 231-242: Age of the auriferous gravels of the Sierra Nevada, J. P. Smith, pp. 243-258: Geological activity of the earth's originally absorbed gases, A. C. Lane, pp. 259-280: Extramorainic drift between the Delaware and the Schuylkill, E. H. Williams, Jr., pp. 281-296: Geology of parts of Texas, Indian Territory and Arkansas adjacent to Red river, R. T. Hill, pp. 297-338: Lake Cayuga a rock basin, R. S. Tarr, pp. 339-356: Pre-Paleozoic decay of crystalline rocks north of lake Huron, Robert Bell, pp. 357-366: Geologic relations from Green pond, New Jersey, to Skunnemunk mountain, New York, N. H. Darton, pp. 367-394: Trias and Jura in the western states, Alpheus Hyatt, pp. 395-434: The Shasta-Chico series, J. S. Diller and T. W. Stanton, pp. 435-464: Geology of a portion of the Coosa valley in Georgia and Alabama, C. W. Hayes, pp. 465-480: Mica deposits in the Laurentian of the Ottawa district, R. W. Ells, pp. 481-488: Geological sketch of Lower California, S. F. Emmons and G. P. Merrill, pp. 489-514.

The National Geographic Magazine, vol. 5, pp. 154-160, Jan. 31, 1894, contains: The relations of geology to physiography in our educational system, T. C. Chamberlin.

The Journal of the Cincinnati Society of Natural History, vol. 16, no. 4, Jan., 1894, contains: Mineral synthesis, G. P. Grimsley: Manual of the paleontology of the Cincinnati group, Part V, J. F. James.

Transactions of the Texas Academy of Science, vol. 1, no. 2, contains: The non-metallic mineral resources of the state of Texas, W. H. Von Streeruwitz.

Journal of the Elisha Mitchell Sci. Soc., 10th year, 1st part, 1893, contains: Notes on the deflective effect of the earth's rotation as shown in streams, Collier Cobb.

III. Papers in Scientific Journals.

Journal of Geology, Vol. 2, No. 1, Jan.-Feb., 1894, contains: The distribution of ancient volcanic rocks along the eastern border of North America, G. H. Williams: Revolution in the topography of the Pacific coast since the auriferous gravel period, J. S. Diller: The name "Newark" in American stratigraphy: a joint discussion, G. K. Gilbert and B. S. Lyman: An abandoned Pleistocene river channel in eastern Indiana, C. S. Beachler: Studies for students:—Physical geography in the university, Wm. M. Davis: Summary of current Pre-Cambrian North American literature, C. R. Van Hise.

Journal of Geology, vol, 2, no. 2, Feb.-March, 1894, contains: The glacial succession in Norway, A. M. Hansen: Dual nomenclature in geological classification, H. S. Williams: Origin and classification of the greensands of New Jersey, W. B. Clark: The nature of coal horizons, C. R. Keyes: The Arkansas Coal Measures in their relation to the Pacific Carboniferous province, J. P. Smith: Pseudo-cols, T. C. Chamberlin: Note on the English equivalent of Schuppenstruktur, W. H. Hobbs: Geological surveys of Missouri, Arthur Winslow.

American Journal of Science, Vol. 47, Feb., 1894, contains: Chemical composition of staurolite, and the regular arrangement of its carbonaceous inclusions, S. L. Penfield and J. H. Pratt: Carboniferous insects of Commentry, France, S. H. Scudder; Harrisburg terraces, H. B. Bashore: Additional species of Pleistocene fossils from Winthrop, Mass., R. E. Dodge; Amount of glacial erosion in the Finger-Lake region of New York, D. F. Lincoln: Basalts of Kula, H. S. Washington: Fishing banks between Cape Cod and Newfoundland, Warren Upham.

Amer. Jour. Sci., vol. 47, March, 1894, contains: Continuity of the Glacial period, G. F. Wright: Chemical composition of chondrodite, humite and clinohumite, S. L. Penfield and W. T. H. Howe: Deformation of the Lundy beach and birth of lake Erie, J. W. Spencer: Crystallization of enargite, L. V. Pirsson: Relations of the Lower Menominee and Lower Marquette series in Michigan (Preliminary), H. L. Smyth: Restoration of Camptosaurus, O. C. Marsh.

The same, vol. 47, April, 1894, contains: Further studies of the drainage features of the upper Ohio basin, T. C. Chamberlin and Frank Leverett: The Post-Eocene formations of the Coastal plain of Alabama, E. A. Smith: Variscite from Utah, R. L. Packard: The appendages of the pygidium of Triarthrus, C. E. Beecher: On the geological position of the Eocene deposits of Maryland and Virginia, G. D. Harris; Contributions to the crystallization of willemite, S. L. Penfield; On the occurrence of Olenellus in the Green Pond Mountain series of northern New Jersey, with a note on the conglomerates, C. D. Walcott; Notes on the nickeliferous pyrite from Murray mine, Sudbury, Ont., T. L. Walker.

American Naturalist, vol. 28, March, 1894, contains: On a small collection of vertebrate fossils from the Loup Fork beds of northwestern Nebraska, with note on the geology of the region, J. B. Hatcher.

IV. Excerpts and Individual Publications.

The ore deposits at Franklin Furnace and Ogdensburg, N. J., J. F. Kemp; Trans. N. Y. Acad. Sci., Vol. 13, pp. 76-98.

Observations on the geology and botany of Martha's Vineyard, Arthur Hollick; Trans. N. Y. Acad. Sci., vol. 13, pp. 8-22.

The Devonian section of central New York along the Unadilla river, C. S. Prosser; 12th Ann. Rept. of the State Geologist (New York) for 1892, 35 pages, 1894.

Age of the Newark brownstone, B. S. Lyman; Proc. Amer. Philos. Soc., vol. 33, pp. 5-10, 1894.

Further observations upon the occurrence of diamonds in meteorites, O. W. Huntington; Proc. Amer. Acad. Arts and Sciences, vol. 29, pp. 204-211, 2 plates.

The work and scope of the Geological Survey, C. R. Keyes. Iowa Geol. Survey, vol. 3, Ann. Rept. for 1893, pp. 47-98.

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CORRESPONDENCE.

Note on the Chehalis Sandstone. The writer had occasion recently to spend a day at the town of Chehalis, Washington. While there he found some fossils, the occurrence of which it may be of service to record. On the east side of the town is a low range of hills. On the east side of the ridge nearest the town a reservoir has been constructed. From the reservoir the water is piped through the ridge by means of a tunnel. It was the dump of this tunnel which attracted the writer's attention as a favorable spot to ascertain something of the geological character of the ridge. The rock thrown out of the tunnel is a sandstone of variable character. For the most part it is soft and friable. It is generally clayey, and its color varies from bluish gray to yellowish, according to the stage of oxidation. A section is exposed in the cuttings above the reservoir, but the bedding is indistinct. The rocks in general are very similar to the soft sandstones which have thick and extensive beds of lignite associated with them in the vicinity of Chehalis. It is very probable that the sandstones in which the fossils occur and those in which the lignites occur are part of the same geological series. The fossils have been submitted to Mr. T. W. Stanton of the U. S. Geological Survey, who has kindly examined them. He reports that "they include species of Solen, Lida, Tellina, Venus, Fusus, Dentalium, and others. As these are all marine forms they cannot be compared with the brackish water fauna of the Puget group. Two or three of the species resemble Tejon (Eocene) forms, but as the material is not sufficient for positive identification, and as closely related species also occur in the Miocene, it is not possible to assign them to a definite horizon. They are either Eocene or Miocene."

The interest attaching to these fossils is their bearing on the correlation of the Puget group, which comprises the lignite-bearing formations of Washington. The sediments composing it are very voluminous, and the presence of the lignites gives it considerable economic importance. So far, however, the age of the Puget group has not been precisely determined, from the fact that the fossils found in it are not marine and are therefore not easily compared with those of possibly equivalent formations of the coast. Here, at Chehalis, we have marine fossils, which are either Eocene or Miocene, in a portion, apparently, of the lignite-bearing series. If the occurrence of lignites in thick and repeated beds may be taken as a diagnostic feature of the Puget group, we seem here to have the marine extension of the estuarine formations recognized by Dr. White as constituting the bulk of that group of strata. The fossils here reported were collected hurriedly in less than an hour. A more careful examination of the field would doubtless yield sufficient fossils to determine definitely whether the Chehalis sandstone is of Eocene or Miocene age, and it is the writer's hypothesis that this would also determine the age of the Puget group.

ANDREW C. LAWSON.

Geol. Laboratory, Univ. of California, Berkeley, Cal., Jan. 29, 1894.

NOTE ON THE KEWEENAWAN ROCKS OF GRAND PORTAGE ISLAND, NORTH COAST OF LAKE SUPERIOR. In his monograph on the copper-bearing rocks, Prof. R. D. Irving states that on this island can be seen the junction between the Keweenawan and the uppermost beds of the Animikie (Upper Huronian.)* Since then little light has been thrown on the relations of these two series in Minnesota, and the writer is aware of no other published interpretation than that given by Irving having been put on the rocks of this island.

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*The Copper-Bearing Rocks of Lake Superior; U. S. Geol. Survey, Mon. V, pp. 297, 367, 405, and fig. 16 on p. 297; 1883.

Grand Portage island lies in the mouth of a bay of the same name in T. 63-6E., Cook county, Minnesota. The rocks of the island have been described by Prof. N. H. Winchell;* they consist of sheets of sedimentary and igneous rocks dipping southeastwardly at a small angle into the lake. The lowest beds exposed are at the northeast corner of the island; they consist of coarse and fine grained sandstones and arenaceous slates. They are cut and overlain by sheets of basic igneous rocks (at least a considerable part of which are effusive), which dip in entire conformity† with the underlying clastics. The lowest exposed layers of the sandstone are decidedly conglomeratic, the foreign pieces often being several inches across. These conglomeratic beds are composed largely of fragments of quartz, gray and reddish quartzite, siliceous slate, a dark flinty rock, red quartz porphyry and red granite. Most of these, more especially the quartz pebbles which make up the bulk of the rock, are clearly water-worn and well rounded. The quartzite and slate pieces are similar to those occurring just to the north and northeast in the Animikie strata, and the same can be said of the quartz porphyry and granitic pebbles. In fact all the pebbles of the conglomerate can be matched in the Animikie strata near by. The red quartz porphyry and granite have been shown to be, at least in their present condition, later than the Animikie,‡ and rocks of this nature, which could have furnished the pebbles in the conglomerate under discussion, do not seem to be known in this region, except in the Animikie and later series. Moreover, the alteration and recrystallization of the Animikie sandstones, pebbles referable to which occur in the conglomerate, date from the same time as the quartz porphyry and granite. In addition to the fact that the pebbles of the conglomerate can be referred to the Animikie rocks close at hand much better than to any others, is the fact that the sandstone and conglomerate of Grand Portage island do not show evidence of having been subjected to metamorphosing forces, as do the sandstones of the Animikie in the immediate vicinity.

It thus seems evident that the clastics of Grand Portage island can not be referred to the Animikie, as has been done hitherto, but that they probably represent one of the lower parts, if not the lowest, of the Keweenawan in this locality: and that the contact formerly considered as here existing between the Animikie clastics and the Keweenawan eruptives is really that between two parts of the Keweenawan itself. For a considerable distance to the west of this place the lowest rocks of the Keweenawan as far as known are entirely eruptives, but where the lower part of the Keweenawan first occurs to the east (on the east side of Thunder bay) the lower member consists of a considerable thickness of sandstones, and it is with these that the clastics of Grand Portage are probably to be correlated.

The above only serves to emphasize the existence, already agreed upon by Lake Superior geologists, of an erosion interval between the Animikie and Keweenawan; and it also, if we provisionally assume that the Grand Portage island conglomerate represents the earliest part of the Keweenawan, points to the intrusion of the great gabbro or diabase dikes of Pigeon point and Grand Portage and the consequent modification of the Animikie strata at a date earlier than the Keweenawan, very probably during the period of elevation in which the Animikie sediments were raised above the sea. Although it is likely that the clastic rocks of Grand Portage island represent the earliest part of the Keweenawan, still this is not proven.

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*Geol. and Nat. Hist. Surv. of Minn., 10th (1881) Ann. Rept., pp. 45-46; 1882.

†R. D. Irving; *op. cit.*, p. 367.

‡W. S. Bayley; The Eruptive and Sedimentary Rocks on Pigeon Point, Minnesota, and their Contact Phenomena; U. S. Geol. Survey, Bull. 109; 1893.

Prof. N. H. Winchell, whom the writer accompanied to the locality above described under the auspices of the Geological and Natural History Survey of Minnesota, fully agrees with the opinion here expressed in regard to the age of the clastics of Grand Portage island.

Minneapolis, Minn., May 8th, 1894. U. S. GRANT.

PERSONAL AND SCIENTIFIC NEWS.

HANDBOOK OF THE BRACHIOPODA. There probably was never a more striking and admirable illustration of persistence and success in a tedious scientific research, crowned at last with a perfect finale, according to the long cherished design and ambition of its author, than the *Handbook of the Brachiopoda* lately issued by Prof. James Hall. From time to time Dr. Hall has given, in his papers, glimpses of his work and of his success, and all students of the paleozoic faunas have taken a keen interest in his progress, and have lamented the occasional and very discouraging delays which he has experienced. Only the first part of the work has been issued. It illustrates the educational value of the long researches in which Prof. Hall has been engaged. When it is completed, which is promised in the next annual report of the state geologist, it will be a valuable book to put into the hand of every student of geology, and its publication will be a most fortunate event for American geology. The book in every respect maintains the creditable position which New York state has long held in geological science. The authorship is essentially that of Prof. Hall, but he has had various assistants, and latterly Prof. J. M. Clarke has been closely associated with his work. Without attempting a review of the work, we can here only express our conviction that this manual has nowhere its equal as an exposition of the brachiopoda. We hope that the veteran geologist will meet with no further obstacles to the completion of his plan.

An expedition to Greenland, under the command of Dr. F. A. Cook, the ethnologist of the Peary expedition, will sail from New York about June 25th, expecting to reach Melville bay and the Peary headquarters about a month later. Prof. G. F. Wright of Oberlin, O., Prof. B. C. Jillson of Pittsburg, Pa., and Mr. Dove of Andover, Mass., will go with the expedition, to devote a month or more to explorations of the borders of the Greenland ice-sheet. On their return it is expected to reach New York about Sept. 10th.

Mr. Charles R. Keyes, late assistant geologist of Iowa, has been appointed state geologist of Missouri, in place of Arthur Winslow.

Dr. Joseph de Szabo, the distinguished geologist and petrographer, professor in the University and president of the Geological Society of Budapest, Hungary, died at his home in that city April 10th, 1894, in his 73rd year.

The death of Mr. Charles S. Beachler of Crawfordsville, Ind., which occurred April 5 at his home, deprives the State of Indiana of one of her most promising young geologists. It was due to a complication of diseases affecting the heart and lungs. He had been known for some time as an industrious and discriminating local student of the geology of Indiana, and as a collector of fossils from the Lower Carboniferous. Several of his papers have been published in the Geologist, others have appeared in the American Naturalist, and his latest was in the Journal of Geology. He was carefully laying the foundation for a successful if not a brilliant career as an American geologist.

We have the further sad intelligence of the death of Mr. W. H. Scofield, of Cannon Falls, Minn., which occurred at his home in April. He had been a diligent collector of the Lower Silurian fossils in his neighborhood for many years, and had a wide correspondence with the palæontologists of this country. He had aided the Minnesota Survey in the preparation of Vol. III of the final report soon to be published, and is joint author with Mr. Ulrich of a chapter on the Gasteropoda of the Lower Silurian of Minnesota. Originally a teacher, he engaged later in mercantile affairs, and went to the quarries and the bluffs as recreation from business. He was mayor of Cannon Falls. He took great interest in the construction of the new high school building, just completed, of which he was the guiding, inspiring and controlling spirit. He declined nomination to the last state legislature of Minnesota, his brother being nominated and elected in his place. He was sympathetic in his nature, and respected and even loved by every citizen. At his funeral the whole community was in grief.

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ERRATA.

On p. 94, line 14 from the bottom, for "disturbed," read distorted;
line 6 from the bottom, for "Peter" read Pelee.
On p. 95, line 7, for "quercic," read generic.

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